

Unfold studio: supporting critical literacies of text and code

Chris Proctor and Paulo Blikstein

Graduate School of Education, Stanford University, Palo Alto, California, USA

Critical
literacies of
text and code

Abstract

Purpose – This research aims to explore how textual literacy and computational literacy can support each other and combine to create literacies with new critical possibilities. It describes the development of a Web application for interactive storytelling and analyzes how its use in a high-school classroom supported new rhetorical techniques and critical analysis of gender and race.

Design/methodology/approach – Three iterations of design-based research were used to develop a Web application for interactive storytelling, which combines writing with programming. A two-week study in a high-school sociology class was conducted to analyze how the Web application's textual and computational affordances support rhetorical strategies, which in turn support identity authorship and critical possibilities.

Findings – The results include a Web application for interactive storytelling and an analytical framework for analyzing how affordances of digital media can support literacy practices with unique critical possibilities. The final study showed how interactive stories can function as critical discourse models, simulations of social realities which support analysis of phenomena such as social positioning and the use of power.

Originality/value – Previous work has insufficiently spanned the fields of learning sciences and literacies, respectively emphasizing the mechanisms and the content of literacy practices. In focusing a design-based approach on critical awareness of identity, power and privilege, this research develops tools and theory for supporting critical computational literacies. This research envisions a literacy-based approach to K-12 computer science which could contribute to liberatory education.

Keywords Critical literacy, Computational thinking, Literacy, Design-based research, Computer science education, Computational literacy, Multiliteracies, K-12 computer science education

Paper type Research paper

Introduction

Literacy is about much more than learning to read and write. The practices which emerge within networks of people and texts often have prosaic goals such as conveying messages, documenting agreements and establishing authority, but they can profoundly reshape participants' cognition, identity practices and social relationships. Ong (2013) argues that privileged access to reading and writing led to the emergence of new social roles high in the status hierarchy, and that widespread literacy in a society "restructures consciousness" (p. 77) by synchronizing frames of reference such as dates, facts and perspectives on the world. In addition to supporting practices which define social roles and relationships, Scribner and Cole (1978) found that reading and writing were associated with changes in individual cognition such as improved abstract communication, memory and language analysis skills (pp. 27-29). It is not necessary to argue for a direct causal link between

This research was supported by a grant from TELOS, Technology for Equity in Learning Opportunities, by Stanford's Transformative Learning Technologies Lab, and by the Lemann Center for Entrepreneurship and Educational Innovation in Brazil. The authors are deeply grateful to the teachers and students with whom they conducted this research, and to the colleagues who have read drafts of this article.

Received 15 May 2018
Revised 23 February 2019
Accepted 25 February 2019



Information and Learning
Sciences
© Emerald Publishing Limited
2398-5348
DOI 10.1108/ILS-05-2018-0039

reading and writing and cognitive change, rather they may be seen as tools which have the potential to spur a different developmental path for the individual and for the society (Vygotsky, 1980).

Societies all over the world are increasingly becoming reliant on digital media, sometimes in place of print text. Digital media functions differently from print text (Murray, 2017), so we should expect digital literacies to function differently from print literacies. The designers and technologists who invented personal computing were inspired by not just by technological possibilities but also the possibility of new ways of living (Markoff, 2005). Engelbart (1962) pursued augmented cognition through *bootstrapping*, a reciprocal process by which technological advances allow new forms of cooperation and collaboration, which enable further technological advances. Interfaces such as virtual reality and ubiquitous mobile computing present not just new information channels but also “material exteriority” (Hansen and Hayles, 2000), extensions and transformations of the body which redefine the subjectivities we may inhabit (Haraway, 2006; Lanier, 2010). Nelson's (1974) development of hypertext was motivated by the possibility of new social, political and economic arrangement. In contrast to the view of computers as primarily information-processing machines, we argue that personal computing and the internet have always functioned as technologies of literacy, making possible networks of humans and computers whose practices transform cognition, identity practices and social relations.

Educators who understand learning as situated in contexts of people, spaces, tools, ideas and purposes (Collins and Greeno, 2011) recognize the importance of bringing students into communities of practice which engage with media in discipline-specific ways. They also recognize the potential of new media to support the development of new cognitive and social structures (Pea, 1985). One goal of this article is to bring together two distinct research communities concerned with pedagogy, literacy and new media. The first includes learning scientists interested in how computers can support thinking and learning. The second includes scholars of critical multiliteracies interested in how the same literacy practices which can be so empowering also reproduce oppressive subjectivities and power hierarchies, and in strategies for resisting and subverting them. The spread of computation into all aspects of our lives, and the growing awareness that “Silicon Valley is not your friend” (Cohen, 2017), makes it urgent that we integrate these two perspectives into an understanding of critical computational literacies.

The learning sciences are concerned with the mechanisms by which people think and learn with technology, individually and as participants in larger systems (Bransford *et al.*, 2000; Nathan and Wagner Alibali, 2010). Building on early socio-cultural theory, the learning sciences have produced functional accounts of literacy (diSessa, 2001), as well as complementary constructs, describing how communities think and learn through interaction with media. These include distributed cognition (Cole and Engeström, 1993; Pea, 1993), activity theory and figured worlds (Holland *et al.*, 2001). Within these theoretical frames, design-based research (The Design-Based Research Collective, 2003; Bang and Vossoughi, 2016) develops new technologies to understand and improve learning. These include Papert's Logo (1980); diSessa (2000) and more recent computational media (Sipitakiat, Blikstein, and Cavallo, 2004; Barab *et al.*, 2005; Resnick *et al.*, 2009).

A second research community on literacy pedagogy is focused on multiliteracies (New London Group, 1996), a term which draws attention to “the multiplicity of communication channels and media, and the increasing saliency of cultural and linguistic diversity” (p. 63). Multiliteracies stands in a figure-ground relationship with the learning sciences approach to literacies, emphasizing sociocultural issues of identity, voice, positionality and power. Bringing attention to the ways dominant literacies also marginalize and disempower

demands taking a critical stance. Freire's (1968) political activism teaching the poor to read was grounded in a recognition that text-mediated thought was responsible for constituting them as passive subjects incapable of action. Learning to read the wor(l)d means participating in social meaning-making instead of taking meaning as given, realizing that the present world is constituted in certain ways and could have been different, and working toward more just and inclusive futures. (When the term critical is used in this article, it is in this sense.) In addition to contesting the hegemony of dominant literacies, critical multiliteracies aim to re-value marginalized literacies as legitimate meaning-making processes in and out of school (Paris, 2011; Morrell, 2015).

These two traditions have not been sufficiently in dialogue with one another, respectively emphasizing the mechanisms and the content of literacy practices (Bang *et al.*, 2007; Vossoughi and Gutiérrez, 2016). As educators and practitioners within both textual and computational literacy spaces, the authors are interested in studying the material and critical possibilities of textual-computational multiliteracy. This research adopts the methodology of participatory design research (The Design-Based Research Collective, 2003; Anderson and Shattuck, 2012; Bang and Vossoughi, 2016), working iteratively with adolescents to design and build a Web application that supports critical practices, drawing on both writing and programming and collaborating with participants to interpret the results. The starting point is the existing medium of interactive storytelling, which has the affordances of both writing and programming and a history of critical resistance to the sexism, racism and heteronormativity common in mainstream video games (Anthropy, 2012). The research questions guiding these studies are:

- RQ1. What kind of medium and pedagogy might support textual-computational multiliteracy?
- RQ2. What practices might emerge in such a textual-computational multiliteracy space?
- RQ3. How might such practices support critical awareness and resistance to racism, sexism and other oppressive ideologies?

This article is structured around multiple iterations of design-based research developing a Web application for interactive storytelling called Unfold Studio. The next section grounds this research in existing literature and develops a conceptual framework for tracing how the affordances of computational media support different rhetorical practices, producing different meanings and identities and ultimately the possibility of critical activism. Then this framework is used to analyze the iterative development of Unfold Studio, a Web application for interactive storytelling. Finally, the article reports on an interactive storytelling workshop which demonstrated that interactive storytelling can effectively support critical textual-computational literacy. The article concludes with a discussion of how these results contribute to theory and pedagogical practice.

Background

Literacy spaces

This article considers literacy to be a particular form of situated learning (Collins and Greeno, 2011) in which a network of actors collaborate to do semiotic work. Actors may include people, texts, computers, objects, ideas: anything which engages in meaning-making, or which represents, interprets or mediates meaning, or which is marked as meaningful. The abstract term *actors* is used so the definition can include conventional communities reading and writing texts as well as scenarios where it is harder to distinguish

between the authors and the media. In computational literacy spaces, computers function as semiotic media but may also introduce new ideas, engage in interpretation and author their own identities. Computer programs are texts written by programmers, but given the right environment, they can also function as authors, interlocutors or as interfaces mediating readings of other texts. Chatbots, online avatars and news feeds have complex relationships with the people who designed them, who control them and whom they purport to represent. The question of agency is urgent, but not easy to answer.

Gee's (1990) term *literacy space* is used as a near synonym for *literacy community* or *figured world* (Holland *et al.*, 2001), following his rationale that it is unproductive to try to define the membership boundaries of a literacy community. Would-be participants may be excluded, while others may become implicated in a literacy space without their consent. A literacy space is similar to a *Discourse* (Gee, 1990) or an *ideology*, although the latter two tend to be larger networks with longer histories, so that participants are less able to transform meanings within them. For example, Reyes (2017) documents how students within a school literacy space in the USA were able to contest local stereotypes about what it means to be Asian and author new identities for themselves, but they had to work within more widespread ideologies about Asianness, Whiteness and legitimacy.

What kinds of interactions qualify as semiotic work? First, transforming old meanings into new ones. Holland *et al.* (2001) describe a process of “symbolic bootstrapping” (p. 38) or “heuristic development” (p. 40) by which actors take up external tools (or ideas or symbols), use them, internalize them as part of their developmental histories and thereby render their environments useful or meaningful in new ways. The pattern for this process is Vygotsky's (1980) account of how people acquire language and build concepts. For Holland *et al.*, Bakhtin's (1981) heteroglossia – the recursive composition of meaning from prior meanings – runs parallel to the Vygotskian process of tool and concept construction. A point Vygotsky, Bakhtin and Holland *et al.* emphasize is that the generation of new meanings is grounded in and constrained by existing materials which always have histories. Each participant acts from a history of participation which encodes the meanings of other actors, and so continued participation sustains the historical meanings of the system.

The meanings of selves within literacy spaces develop via the same process. This article uses the term *identity* to denote a model of selfhood one authors and occupies in a literacy space, which exists at the interface “between intimate discourses, inner speaking, and bodily practices formed in the past and the discourses and practices to which people are exposed, willingly or not, in the present” (Holland *et al.*, 2001, p. 32). Drawing again on Bakhtin's dialogic self, Holland *et al.* describe identity as the negotiated meeting place of unconstrained inner speech and an external subject position made available by social meanings. The subject position specifies the terms by which one is addressable and by which one will answer.

What we call identities remain dependent upon social relations and material conditions. If these relations and material conditions change, they must be 'answered,' and old 'answers' about who one is may be undone (Holland *et al.*, 1998, p. 189).

Analytical framework

This article's research questions contain an implicit chain of hypotheses:

- that the perceived affordances of a computational medium could shape the rhetorical practices for which it is used;

-
- that these practices could shape the meanings and identities which are thereby enacted; and
 - that these meanings and identities could open possibilities for critical understanding and activism.

This paper's analysis follows a four-layer analytical framework aligned with these hypotheses: affordances, rhetoric, figured meanings and critical possibilities. Similar to [Brooke's \(2009\)](#) framework for analyzing digital rhetoric at the levels of code, practice and culture, each level permits analysis of the literacy space at a different scale.

The following subsections address each layer in turn, grounding its approach in prior literature and explaining how it is operationalized in this research. It may appear anachronistic to present this framework here, as its form emerged during the iterative design-based research described in the next section, and it was formalized during iterative rounds of grounded theory-based open coding ([Charmaz, 1996](#)) described in the subsequent section. However, starting with the framework allows for a more intuitive organization of the results which follow.

Affordances. The development of a literacy medium can be analyzed in terms of its affordances, or the ways it can be used to create meaning. The primary form of meaning-making considered by this research is authors composing texts to shape the experiences of readers. A second form of meaning-making, important to the critical possibilities of literacy, is the way texts can open new possibilities for future authorship. [Norman \(1999\)](#) distinguishes between affordances and perceived affordances – between the actionable properties of an object and those perceived as such by a user. When considering media which support literacy, this means distinguishing between the myriad ways a medium could potentially be taken up in meaning-making, and the subset authors perceive as likely to be recognized by an audience, within the context of the Web application interface. Therefore, this article analyzes the perceived affordances of media through instances of their use.

The two media with which this article is most concerned, i.e. text and code, function differently in supporting meaning-making and therefore offer different affordances. Although in practice literacies are multi- and trans- ([New London Group, 1996](#); [Thomas et al., 2007](#)), there is value in distinguishing how reading a text differs from playing a computational artifact such as a game or an interactive map ([Aarseth, 1997](#)). One essential mechanism of text is representation. Representation can be achieved in many ways, such as evoking sensory experiences through descriptive language, voicing characters through dialogue and setting the mood through emotional descriptions of the setting. Rather than understanding representation as encoding some objective meaning, this framework takes a reader-response stance, viewing representation as offering provocations and opportunities to the reader. In [Rosenblatt's \(1968\)](#) account of reading as a unique, historically grounded transaction between a reader and a text, each is transformed. The reader's identity is changed through her response to the text, which then reciprocally transforms the text's possible meanings ([Barthes, 1981](#)).

One way we can interact with computation is through modeling or simulation. Interacting with computational models is a central practice in science ([NGSS Lead States, 2013](#); [Blikstein, 2014](#)) and computer science ([K-12 Computer Science Framework, 2016](#)). Interacting with a model can be agent-based, emphasizing how one actor in the system can affect others, or systemic, emphasizing emergent properties ([Weintrop et al., 2016](#)). [Papert \(1980\)](#) used the term *microworlds* to describe computational models or simulations in which one can immerse oneself and learn how the world works through play or exploration. This can lead to authentic, embodied knowledge, more like getting to know someone than

learning a fact. For example, NetLogo (Wilensky, 1999) is an environment for modeling of dynamic systems. Participating in a NetLogo simulation can help students understand and predict the behavior of systems from both an agent-based and a system-level perspective (Wilensky and Stroup, 1999). This article considers microworlds to be both models and games[1].

Interactive storytelling combines the affordances of text and code in ways that are difficult to classify, so the modes of interaction described in the previous two paragraphs are best understood as heuristics for the affordances authors might perceive in interactive storytelling, as instantiated in the Web application's interface. Much of the participatory design process developing the Web application was devoted to discovering the ways authors could use interactive storytelling and refining the interface and pedagogy to make those affordances more perceptible.

Rhetoric. The second layer, rhetoric, is focused on how authors use the affordances of media to create meaning. Theorists of digital rhetoric have argued for the importance of this link: whereas traditional literary criticism could assume some universality to how text functions, digital media cannot be understood apart from the affordances of its media (Wysocki, 2004; Bogost, 2007; Brooke, 2009). Digital interfaces such as hypertext, interactive stories, Instagram and mobile phones have such diverse affordances that the rhetorical possibilities of each are quite distinct.

The interactive storytelling community has identified several broad categories of rhetorical moves (Glassner, 2004; Montfort, 2007; Murray, 2017). Ryan (2001) contrasts immersion with interactivity. Reading a story can involve constructing a world of meanings around oneself through a transactional reading process. The reader potentially experiences immersion, a sense of being embodied in and surrounded by that world. In contrast, when playing an interactive story which functions as a microworld, it does the work of simulation and its world is perceived as outside of oneself. The player experiences interactivity, with a heightened awareness of the interface. There may be a tradeoff between these rhetorical modes in interactive storytelling: the more the story handles the simulation (functioning as a microworld), the more one can interact with dynamics that are too hard to simulate or which one could not have imagined. The more the reader is left to do the simulation (as with a representational text), the more she can experience intimacy and empathy through immersive embodiment.

This article's analysis of the rhetoric of interactive storytelling extends traditional reader-response literary analysis to include what Bogost (2006a, 2006b) calls procedural rhetoric, or the ways computational affordances are used to influence an imagined player. The focus is on how stories are crafted to make available possible readings. When available, participants' reflections on their intentions are used to support this analysis. Common interactive techniques include providing or denying agency to the player, allowing omnipotent control of the world (for example, allowing the player to choose the reactions of others or whether it rains) and inserting parenthetical remarks on the player's choices. Immersive techniques include allowing the player to construct an in-world identity and structuring choices so that the player becomes morally implicated in the story's events or is presumed to have given consent to events taking place in the story.

Figured meanings. The third layer, figured meanings, describes the potential effects of rhetorical techniques used by interactive stories. These may include how others read the story and respond by reshaping their own identities, as well as by reshaping the sense-making processes available for reading other texts. Following the earlier definition of identity as the interface between internal self-conception and externally imposed subjectivities, changes to figured meanings may expand or contract the kinds of identities

possible within the literacy space. As a concrete example, when a literature class reads texts featuring characters with potentially invisible life experiences such as being immigrants, queer or homeless, these possible selves become more available to students' identities.

In the participatory design process, one common way interactive stories reshaped sense-making processes was by invoking existing genres or developing new genres. Genres include literary genres such as horror, science fiction and role-playing games, as well as what Bakhtin and Holquist (1981) call speech genres, or the “sphere[s] in which language is used [and] develops its own relatively stable types” (p. 60). In their stories, participants used speech genres including quizzes, text messaging conversations and Facebook posts. Story topics, such as family, friends, dating and school, function similarly to speech genres in that they create expectations for the kinds of meanings that will be expressed. To be recognized, an author or speaker must adopt a register, a socially recognized form of communication which indexes some qualities of the speaker (Agha, 2005). By introducing speech genres in their stories, participants pushed for social recognition of new registers within the literacy space.

Critical possibilities. Finally, the fourth layer, critical possibilities, are ways in which stories enact or hold open the possibility of critical change. This article refers to *critical literacy practices* as those with the potential to enact transformation both within the literacy space (by changing the actors or the sense-making processes) and also beyond the literacy space (Gee, 2004a, 2004b). Fairclough (2004) refers to the *performativity* of texts as their “causal effects on nonsemiotic elements of the material, social, and mental worlds and the conditions of possibility for the performativity of texts” (p. 225).

When people find themselves within oppressive literacy spaces, where the existing language and cultural materials offer only marginalized subject positions, there are several possible responses. One might refuse to participate, retreating into the space of inner speech where for Bakhtin (if not for Vygotsky), one is free to fashion a self. One might also try to “use the master's tools to dismantle the master's house” (Lorde, 2003), or insist on the inclusion of other materials, for example, by legitimizing vernacular registers (Anzaldúa, 1987). Discovering and using critical strategies depends on understanding how identities are circumscribed by available subjectivities, and how registers are legitimized.

The goal of Freirian critical literacy is to develop this understanding. Freirian critical literacy depends on the representational function of text: once people become aware of the parallels between reading the word and reading the world, they may realize that neither has a fixed meaning, but rather the meanings of each are continually produced within a literacy space, and that the possible meanings are co-produced with one's identity. Of course, as mentioned earlier, it is much easier to open new possibilities for identity and register within a small discussion group than it is within the context of ideologies that span centuries and continents.

The computational affordances of interactive stories support additional critical possibilities (Bogost, 2007; Blikstein, 2008; Garcia *et al.*, 2015). One powerful dynamic which emerged in the participatory design workshops was using interactive stories to model literacy spaces themselves. For example, participants wrote stories allowing the player to experience how one is treated differently when speaking English versus when speaking Spanish, or how two friends in casual conversation can also be engaged in a struggle to position each other. These stories foreground otherwise-latent uses of power within the literacy space, making them visible and accessible for analysis and critique. These stories potentially function as *critical discourse models*, a particular kind of what Vossoughi (2014) refers to as social analytic artifacts, or “tools that deepen the collective analysis of social problems” (p. 353).

Players of critical discourse models participate in the story's simulated literacy space. At the same time, the player and the story are both actors within a larger literacy space. The idea of a nested literacy space as an actor within a larger literacy space is not new: Bakhtin's (1981) multivocal understanding of texts in dialogue with existing meanings and [Minsky's \(1988\)](#) understanding of minds composed of many agents may each be understood as literacy spaces functioning as actors within larger literacy spaces. However, the distinct affordances of interactive stories (particularly the precision with which one can author them) offer unique critical possibilities.

Interactive storytelling

The goals of this research are to develop media and pedagogy capable of supporting textual-computational multiliteracy, to study the practices that might emerge and to assess their critical possibilities. The starting point is interactive storytelling (a generalization of interactive fiction), a medium authored with text and code to create single-player text-based games and stories. Interactive storytelling had a widespread following from the late 1980s through the 1990s, bounded chronologically by the emergence of personal computers and early access to the internet and its displacement by graphical games made possible by improvements in processors and displays ([Labrande, 2011](#)). Over the past several decades, interactive storytelling has retained a small but active community, often articulating feminist and queer critical responses to the ideologies dominant in the literacy space of mainstream video games ([Anthropy, 2012](#)).

Two recent works of interactive storytelling illustrate the dynamics the framework presented in the previous section: these stories use their affordances for immersive and interactive rhetorical effect, producing figured meanings and critical possibilities. In *80 Days* (2014), a choose-your-own-adventure game loosely based on Jules Verne's novel, the player inhabits the role of Passepartout, valet to a wealthy Englishman who is attempting to circumnavigate a counterfactual nineteenth-century world. In choosing how the story should unfold, the player may have very different experiences depending on how she engages dialogically with other characters, and the ways in which she decides to explore beyond the bubble formed by her employer's casually racist, sexist and elitist attitudes. In the interplay between interactivity (making strategic choices) and immersion (becoming invested in the lives of other characters), *80 Days* functions as a microworld in which the player can discover how richly expansive or foreclosed the world (and one's self-authored identity) can be, depending on the extent to which one chooses vulnerability and openness in the face of the unknown. The player potentially realizes that winning the game is not the point.

Nicky Case's *Coming Out Simulator* (2014), an autobiographical "half-true story about half-truths," powerfully demonstrates the capability of interactive storytelling to model how linguistic processes produce our social reality and shape how we can act within them. The game replays the evening during Case's teenage years when he told his parents (or, perhaps, they found out) that he is bisexual. The interface mimics that of a mobile phone, superimposing text message speech bubbles over simple animations and presenting the player with dialogue options. In the prologue, the game highlights the way it functions as a critical discourse model, emphasizing that all the characters remember and respond to everything the player does. As the protagonist struggles to come out to his parents, they are equally committed to preserving their image of him by silencing his attempt at self-redefinition. The story is ultimately about negotiating what it means to be male and to be a good son within a cultural context. It is played through speech acts; the player struggles to

author an identity using language whose categories and meanings are largely under the parents' control.

We engage in these discursive struggles on a daily basis, but because they are fleeting and invisible, they can be difficult to perceive or understand. In contrast to our lived experience or linear narrative, in which we can only follow one path through a space of possibilities, the Coming Out Simulator:

[...] includes dialogue that I, my parents, and my ex-boyfriend actually said. As well as all the things we could have, should have, and never would have said. It doesn't matter which is which.

The game takes no more than 20 min to play through, and it explicitly invites multiple replays through which a player can map out the space of interactional possibilities. In doing so, the player engages in an epistemic game (Collins and Ferguson, 1993) of modeling how characters position themselves and each other and analyzing the how the game's reality is shaped by the characters' speech choices. Both 80 Days and the Coming Out Simulator illustrate the critical potential of interactive storytelling as a medium for textual-computational multiliteracy. Studying language, identity and culture within a computational environment could make it possible to simulate, replay and share these otherwise-elusive phenomena. Reading and writing microworlds in the context of questions usually addressed by literature might imbue computer science, a potentially abstract and impersonal field, with profound personal significance.

Workshops I and II: developing Unfold Studio

This section reports on the initial development of Unfold Studio through Workshops I and II with middle-school students. An iterative design process focused on emergent and imagined interactive storytelling practices helped develop the Web application and the analytical framework described above. These results framed a hypothesis that interactive storytelling could be particularly effective in supporting critical change within and beyond the classroom literacy space. Workshop III designed to test this hypothesis is reported in the following section.

Methods

The workshops developing Unfold Studio took place at a private all-girls' middle school in western USA, at the border of two communities: a wealthy, largely white and East Asian community, and a largely black, Latinx and Tongan community, including many recent immigrants and having a much lower socioeconomic status. Approximately 80 per cent of the students pay full tuition; the majority of students receiving scholarships are Mexican-American and speak Spanish at home. In spite of the structural inequalities that come with charging high tuition, the school's explicit mission is to help its early-adolescent students understand gender, sexuality and race. Students had these analytical registers available to them, but there were also numerous tensions dividing the school that were seldom openly discussed. The first author who led these workshops (hereafter "Chris") had been a teacher at the school several years prior, granting him legitimacy and trust in the eyes of the faculty. Even though he had never worked with these students before, they also accorded him insider status.

Workshop I included 12 participants who met for 3 h each morning over the course of a school week (15 h in all). The participants were consistently positioned as co-researchers. On the first day, Chris introduced interactive storytelling and an initial prototype of the Web application, saying he did not know what it might be good for. He proposed a writer's workshop-like structure, with mini-lessons targeting writing skills such as incorporating

dialogue, developing character, using sensory detail and structuring plot, as well as computational skills such as expressing stories as sequences and branches, using loops and conditionals and using trees and directed graphs to plan their stories. As the week went on, participants increasingly steered the agenda. The final 30 min of each day were devoted to discussing what worked and what did not work in the lessons, planning the following days and critiquing the Web application. Each night the authors updated the Web application guided by the participants' feedback. The authors collected ethnographic field notes, logged interactions with the Web application, analyzed the stories participants wrote and asked the participants to engage in reflective writing at the end of each session.

Workshop II was embedded within a two-week summer program designed to build community amongst students receiving full scholarships to the same school. The participants were 16 incoming sixth-grade students (age, 11-12 years), all bilingual speakers of Spanish and English. Chris also had the opportunity to plan and co-teach the workshop with an incoming eighth-grade student, a college sophomore majoring in creative writing (both alumnae of the same program), and the students' future humanities teacher. This group designed a sequence of three introductory story prompts, and otherwise prioritized time for writing and workshopping stories with optional mini-lessons.

The college student in particular engaged the participants with a powerful writerly presence. In speech and writing, she allowed herself to be vulnerable and direct in her perceptions, unafraid to follow thoughts even when they approached topics that felt taboo. One participant noted:

I was struck by the difference between her real story and my skeleton of a story. Juli's (all participant names are pseudonyms) had an authenticity, a sensory immediacy that was so vivid it was almost uncomfortable.

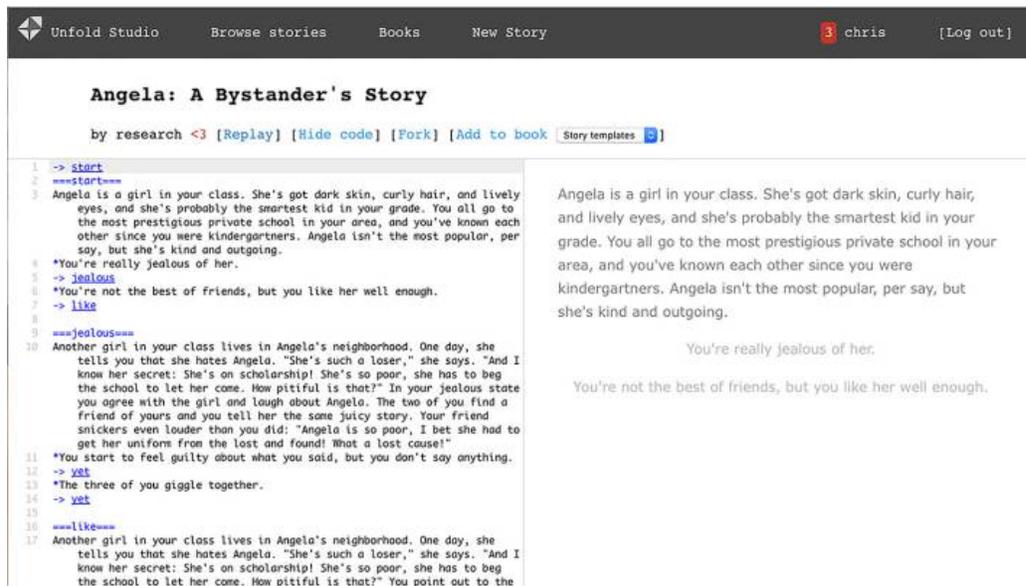
The authors repeatedly noted participants authoring their identities by writing about real issues (and sharing their stories) after Juli opened space to do so.

Development of the application was guided by participants' emergent and imagined interactive storytelling practices. To understand these, the authors analyzed field notes and participants' written reflections using a grounded theory affinity analysis (Iba *et al.*, 2017) in which data were clustered and interpreted. The resulting patterns described how participants recognized affordances in the medium, how they used the medium rhetorically toward figured meanings and how they used the medium for critical analysis.

Results

Developing affordances. The initial prototype allowed users to browse the library of published stories and to select an individual story to play or edit. When viewing an individual story, two panes were presented for editing and playing, in much the same manner as Scratch (Resnick *et al.*, 2009). Stories are written in Ink, a language originally designed to support the development of 80 Days and released as open source in 2016. Figure 1 shows a story written in Ink, demonstrating several of its key structures. The narrative is divided into knots containing anywhere from a phrase to several paragraphs of prose. Typically, a knot ends with several options to be presented to the player, whose consequences are redirects to other knots.

In response to participant feedback, three iterations were released over the course of the week. The participants delighted in suggesting improvements and reporting bugs and checking that the changes had been made. The most frequently requested features were support for additional typefaces, font styles, font sizes and colors. Participants also requested support for visual elements such as background colors and incorporating



Critical literacies of text and code

Figure 1.
Final interface for Unfold Studio

Note: The story's source code is on the left and the running story is on the right

animated GIFs into their stories, user accounts with the ability to mark stories as private and site navigation elements such as the ability to search, star favorite stories and add short descriptions to stories for ease of browsing. Participants came across several situations in which they needed to toggle between a prose-like interface and a code-like interface. Several participants attempted to use accented Spanish characters and emoji in their stories. At the time, Ink did not support unicode, so these characters caused the application to crash.

In both Workshops I and II, participants' use of computational affordances was broad but shallow. In Workshop II, 81 per cent of stories used branching to create nonlinear structure, but less than 20 per cent used other computational affordances such as variables, logic, or randomness, despite mini-lessons focused on exploring their use. One frequently cited constraint was that error messages were not user-friendly. Nevertheless, many participants described the computational concepts as interesting and generative.

Affordances spurred imagination for rhetoric and figured meanings. Over the course of Workshop I, participants explored the nature of interactive storytelling, positioning it with respect to stories, games and computer programs, and playing and critiquing several published examples. These conversations generated a great deal of aspirational discussion about what could be created with interactive storytelling. When participants imagined "being lost" in a story world, "going deeper into characters" and "a world of different types of people," the experiences they described were immersive readings. These generally relied on familiar representational affordances of literary text (also called literary elements) such as sensory detail, characterization and point of view.

Participants also imagined using interactivity, though not for new forms of digital media such as games, agents or simulations of systems. Instead, participants often described a desire to concretize an imagined reader's experience, to connect with the reader and to shape her reading of the story. One participant wrote, "I love it because [...] I feel like a writer [...] you give the viewers the opportunity to make the story their story by choosing what path

they want to take.” This participant imagined using interactive storytelling in much the same way as Graff *et al.*'s “They say, I say” (2006) pedagogical strategy for helping participants understand voice in academic writing, using choices and nonlinear branching to represent possible readings. Helping students learn that reading is an active, interpretive process (Rosenblatt, 1968) rather than one of passive uptake is a central goal of English/Language Arts and Freirian critical pedagogy, made particularly challenging because the student usually cannot observe the practices adopted by the expert reader.

Participants imagined writing various simulations of dialogical encounters, particularly in digital media. They frequently requested the ability to add emoji, GIFs and speech bubbles simulating text message conversations. Participants' desires to appropriate these speech genres into their own storytelling (e.g. embedding texts or tweets into an interactive story) are evocative of Bakhtin's (1981) analysis of how the novel fixes and stylizes other genres, while making them more “free and flexible [...] permeated with laughter, irony, humor, elements of self-parody” (p. 7) by putting them in dialogue with other voices. Social media is already dialogic and constantly changing, but platforms allow only prescribed usage aimed at commodifying the voices, identities and attention of users. The unauthorized uses imagined by these workshop participants point to new strategies for critical engagement with computational media.

Critical discourse models. One prominent theme which emerged in Workshop II was talk about language. One of the initial story prompts asked participants to model a real-life incident where each participant had a different experience. Many participants drew on their bilingualism to model how social reality changes when speaking English and when speaking Spanish. For example, one story considered a multilingual family context in which the player can position herself by drawing on a spectrum of linguistic practices. Others explored discrimination which results from speaking Spanish in public, or represented a multilingual inner voice. These stories functioned as dialogue-based microworlds simulating both heteroglossic possibility and exclusionary language ideologies (Rosa and Burdick, 2016).

The classroom sustained a lively and thoughtful conversation exploring these questions. Field notes and participants' post-workshop reflections document the importance to participants of constructing, revising, playing and discussing these interactive stories. The authors' field notes repeatedly describe participants juxtaposing their desks so that each could face her laptop screen and her partner while reading and writing – an embodied enactment of the literacy space. The stories functioned as what Vossoughi (2014) calls social analytic artifacts, “tools that deepen the collective analysis of social problems” (p. 353). However, the specific method by which the stories functioned, as microworlds simulating discourse within a literacy space, led to a new concept: *critical discourse models*. Critical discourse models may offer experiences which cannot be enacted with immersive representational texts, and introducing them as actors within a literacy space may offer new possibilities for critical literacies pedagogy.

Workshop III: toward critical multiliteracies

The result of Workshops I and II was a medium capable of supporting textual-computational literacy practices through interactive storytelling, and a hypothesis that these practices could be particularly effective in supporting critical change within and beyond the classroom literacy space. Following Schwartz *et al.*'s (2008) suggestion that design-based research ought to move from innovative design toward efficiency, we designed Workshop III to test this hypothesis.

Methods

Workshop III was set in a large comprehensive high-school drawing students from the same communities as the previous studies. The workshop took place over two weeks (15 h total) in students' English and Sociology classes, linked together in a self-selected academic track focused on social justice. Twenty-three high-school seniors participated; two additional students did not return consent forms and were excluded from analysis. The first author co-designed the workshop with several of the students during meetings and email exchanges prior to the workshop, and co-led the workshop with two of the students' teachers. His collegiality with the other teachers conferred legitimacy and some authority, while his intentional self-positioning as a researcher beyond the school's authority may have contributed to participants' willingness to discuss and write about charged topics.

The workshop was again structured as three introductory story prompts introducing affordances of interactive storytelling, followed by writer's workshop time devoted to participants working on, sharing and revising their interactive stories. The final prompt addressed three ideas related critical understandings of discourse:

- *Models of personhood*: In any social world, people inhabit models of personhood which define what kind of person they will be seen as and what they can do.
- *Performativity*: Identities are dynamic, not static. We perform our identities, bounded by models of personhood, but possibly also redefining models of personhood.
- *Register*: A socially recognized way of speaking based in a model of personhood.

Participants were offered several options for exploring the following ideas:

- create an oppressive social world where the possibilities of speech are limited for the main character;
- create a world where the main character is assigned a model of personhood based on how he/she speaks; or
- create a world where the main character subverts a model of personhood he/she is assigned.

As they discussed these prompts, many participants offered examples from their own lives. Many participants continued to develop stories based on these prompts for the rest of the workshop.

Participants' stories were analyzed through multiple iterations of qualitative coding. Initially, the authors relied on open coding via a grounded theory approach (Charmaz, 1996). Over multiple passes of coding, writing integrative memos (Emerson, Fretz, and Shaw, 2011) and refining the coding scheme, the outlines of the analytical framework (presented above) emerged. Two major groups of computational affordances were FLOW, affordances for controlling the flow of story execution, and STATE, affordances for keeping track of the past and using it to affect the future. Of the various textual affordances, DIALOGUE was chosen for further analysis because of its importance for critical analysis of social discourse. Codes for rhetorical strategies were grouped into IMMERSION and INTERACTIVITY. Figured meanings were grouped into three high-level categories: LIFE, for speech genres pertaining to family, dating, friends, jobs, school and drug use; LITERARY GENRE, prominently including science fiction, horror and genres of games such as role-playing games and puzzles; and SOCIAL MEDIA, for stories adopting registers characteristic of texting or other online discourse. Finally, CRITICALITY contains codes for when categories such as race, gender, sexuality and social class are either marked (for example, by noting a

character's skin color or manner of speech) or explicitly addressed by the story. Co-occurrence of codes within stories was calculated to analyze associations between factors at different layers of the analytical framework. The final codebook is included in Appendix 1[2].

Results

The results, shown in [Table I](#), validate the construct of critical discourse models as an effective structure for exploring critical ideas in real-life contexts. Of the stories with critical engagement (CRITICAL), 62 per cent dealt with familiar settings such as family, friends, dating and school (LIFE), 62 per cent used immersive techniques (IMMERSION), 85 per cent used interactive techniques (INTERACTIVITY), 69 per cent used computational affordances to control story flow (FLOW) and 92 per cent relied on dialogue (DIALOGUE). These are precisely the properties hypothesized to be effective for exploring critical ideas.

There was a clear distinction between the use of computational affordances for controlling the flow of story execution (FLOW) and the use of variables to maintain state (STATE). FLOW affordances tended to occur in stories using both immersive (47 per cent) and interactive (71 per cent) techniques, while STATE affordances were seldom used in immersive stories (17 per cent) and more often used in interactive stories (42 per cent). While FLOW stories engaged with LIFE (41 per cent) and LITERARY GENRE (47 per cent) figured meanings, STATE stories focused predominantly on LITERARY GENRE. (The sets of stories coded with LIFE and LITERARY GENRE were disjoint.) Finally, 53 per cent of FLOW stories featured critical engagement (CRITICAL), compared with only 31 per cent of STATE stories. Broadly, these results suggest that FLOW affordances were often important components of critical discourse models, while STATE affordances were more often games or puzzles set in fictional worlds, whose figured meanings had lower stakes.

One particularly interesting set of stories were set in the speech genres of text messaging and social media. These stories effectively made use of affordances and rhetorical strategies such as acronyms, iconic textual effects, emoji and pacing – either the staccato of brief exchanges or ellipses denoting significant pauses. The affordances shared by texting, social media and the interactive storytelling medium have become infrastructural (diSessa, 2000) to identity in many youth cultures. [Holland et al. \(2001\)](#) emphasize that identities are authored within literacy spaces dependent on material conditions; as these conditions change, identities must be articulated anew. The prevalence of social media as a space of youth identity practices may make interactive storytelling particularly valuable for authoring identities and critical analysis of the literacy spaces in which they are authored.

Case study: enacting critical change

A case study of one participant's experience in the workshop shows the potential critical discourse models have to enact change in and beyond the literacy space. In an introductory survey, Leanne describes herself as female, biracial and primarily a speaker of standard English with African-American vernacular English at some family gatherings. Her pre-survey responses suggest a rich history of textual literacy practices, and very little history with computation. Leanne experiences gender-based discrimination frequently and racial discrimination daily. Leanne was an active, but not extremely vocal, participant in the workshop. Some days she sat by herself and worked, other days she sat with a small group of peers. She participated regularly in the quiet conversation taking place while participants read and wrote. In a survey halfway through the workshop, Leanne described having trouble deciding what to write about:

Code (count)	Affordances			Rhetoric			Figured meanings		Criticality	
	Flow (%)	State (%)	Dialogue (%)	Immersion (%)	Interactivity (%)	Life (%)	Literary genre (%)	Social media (%)	Critical (%)	Critical (%)
Flow (17)	100	29	65	47	71	41	47	12	53	53
State (12)	42	100	58	17	42	25	67	25	33	33
Dialogue (22)	50	32	100	59	68	45	32	27	55	55
Immersion (15)	53	13	87	100	73	73	13	33	53	53
Interactivity (21)	57	24	71	52	100	48	43	14	52	52
Life (13)	54	23	77	85	77	100	0	46	62	62
Literary Genre (15)	53	53	47	13	60	0	100	0	20	20
Social media (9)	22	33	67	56	33	67	0	100	33	33
Critical (13)	69	31	92	62	85	62	23	23	100	100

Critical literacies of text and code

Table I. Relative co-occurrence of codes (columns) in stories with codes (rows)

I grasp that I can pull from my own experiences, but I have trouble picking just one. I know that when I do, it could end up being pretty profound, but I haven't been able to zero in on one concept yet.

In the first week, she wrote a fan fiction-style story set in the world of *Dune*, which her English class had been reading. She also reported having some trouble with the programming aspects of interactive fiction: "I think I get the gist of it, but an error occurred on the story I did write. I don't know how I can fix these errors; the explanation given when I click on my story is still confusing to me."

At the beginning of the second week, an incident took place which motivated Leanne to write her final story. During a discussion on register, Mr Leo, a white man who was one of the co-teachers, shared an anecdote in which he had imitated the speaking style of several African-American freshmen girls he did not know well. He described how he had intended the interaction as a joke and a way to connect, but they were extremely offended. He explained that they would not have taken offense if they had been in his class, because they would have known him as someone who likes to tell jokes and understood his intentions. No participant responded to this anecdote at the time, but Leanne addressed it in her final reflection:

I was intrigued by the discussion on personhood and register, and the idea of having no way out of the stereotypes you are assigned. Mr Leo gave an example of register discussing some insensitive things he said to a couple of African-American freshmen girls, saying the same offense wouldn't happen in this class. I disagreed, since I was very offended by his words and conclusion, but didn't say anything in order to not make people (especially Mr. Proctor who I didn't know very well) "uncomfortable." I regretted not saying anything, and I think that regret evolved into my piece.

An excerpt from the story Leanne wrote in response to this incident is included below. Readers may play it as an interactive story by visiting <https://unfold.studio/stories/1063>. The story uses only FLOW computational affordances, offering nonlinear paths through knots (e.g. === start ===) of content. Knots end by presenting the player with options (*) which divert the story to another knot (→). When readers play the story, they see only the text contained within knots and their options. Readers may also choose to view the story's source code in parallel (see [Figure 1](#)).

Leanne's story functioned as a critical discourse model. It enacted critical transformation within the classroom literacy space by indirectly voicing an otherwise-unspoken contestation of Mr Leo's anecdote. The story is written in second-person, which highlights the player's role as a character in the story. The story begins by introducing Angela, a girl in your (presumably high school) class who has "dark skin, curly hair, and lively eyes, and she's probably the smartest kid in your grade" (Line 3). The first choice the player is presented with is not an action in the story but a choice of identity: deciding whether to like Angela or whether to be jealous of her. This is the beginning of a process by which the player self-authors an identity within the story, and thereby makes herself a witness and complicit in the action. Regardless of the player's choice, the plot continues with another girl, making a joke about how Angela is so poor that she probably has to wear second-hand clothing to school. The player is offered at least one opportunity to defend Angela against the attacks (Lines 37, 60, 70). However, the player's protests are ultimately ineffectual. Standing up for Angela only gets the player ostracized too (Line 75).

Angela: A Bystander's Story (Lines 50-73)

50 === yet ===

The rumor gets back to Angela within the week. You keep an eye on her, wondering if she is affected, but she seems to be handling

```

all of this with grace. Angela continues to be a strong student,
and is kind to the people around her. The girl who began the ru-
55 Angela, "You filthy n*gger!" Angela stares at her, stunned, her
unaffected smile completely gone. She looks wounded. You know
that a horrible line has been crossed.
*You are shocked into silence.
-> bullyA
60 *You tell the girl, "That's too far. Stop it."
-> bullyMe
=== bullyA ===
The new game spreads like wildfire. Angela is shoved on the
staircase, excluded
65 from everything. The word "N*gger" echoes through the halls
and is written in Sharpie on her backpack. It scares you how
awful your classmates are being to Angela. You never thought
she was a bad person; what has she done to deserve this? More and
more, Angela reacts to the taunts with a rag doll's indiffer-
ence. Her empty eyes haunt you. At first she looked wounded, but
now she looks dead.
70 *You've had enough. You tell your friends to stop.
-> bully
Me *If you say anything, you know they'll come after you too, so
you say nothing.
-> fear

```

Regardless of the player's earlier choices, she ends up in the pivotal sequence at Line 50, excerpted above. Angela's refusal to be provoked by the mean joke causes the girl to escalate her attacks, which finally overwhelm Angela's composure. The player is faced with two options recapitulating the earlier structure, to either remain in shocked silence or to defend Angela. If the player does nothing, the attacks escalate (Line 63). Angela still does not respond to the attacks, but now instead of "handling all of this with grace" (Line 52), she reacts "with a rag doll's indifference" (Line 68). The player is offered one final chance to stand up for Angela as she goes from looking "wounded" to "dead" (Line 69). If the player stands up for Angela at either opportunity, she reaches one of two possible story endings. For the first time, the player is positioned racially – as a "White N*gger" (Line 77). The story concludes with the player's removal from school. Alternatively, if the player chooses not to defend Angela, the player's life goes on – the player dissociates from Angela and disappears from the narrative altogether. It becomes clear that the racial attacks were always about power: "The girl who started it all is on top of the world, the queen bee; the school is hers now. Angela is so far below her in the social hierarchy that she never has to feel jealous again" (line 88). In both outcomes, the player watches as Angela is dehumanized: she no longer makes eye contact with the player, is described as "IT" (Line 76) and is described as the other students' "plaything" (Line 93). In both endings, the narrator relates that Angela attempts suicide.

In neither outcome is the player able to meaningfully protect Angela; the only choice is whether to be stripped of one's whiteness and subject oneself to the same attacks, or to remain silent. The story offers no way out, nor does it make available exculpation or solidarity. Both immersion and interactivity are at work: the high stakes and appearance of choice invite replay and exploration of the action space in an attempt to find a solution. The parts of the story where the player's action is narrated rather than selected, and particularly the vivid imagery showing

Angela's facade cracking, eyes dimming and progressive dehumanization, implicate the player in the story. A player might feel both inside and outside the story, and the effect could be a transformation of the player's identity within the world of the story as well as in the real world. In refusing to grant the player agency, the story possibly enacts critical change in its literacy space, for example, by arguing against the easy answers of an anti-bullying curriculum claiming that bullying can be stopped by a simple act of moral courage.

The story functioned as a critical discourse model within the workshop. As Leanne wrote in her closing reflection, writing it was an opportunity to think about the dynamics by which someone can be trapped and silenced in models of personhood and a way for her to speak back against her teacher's assumptions. While this did not lead to a confrontation with Mr Leo or a reckoning with his joke, Leanne's story did contribute to change. In the final days of the workshop, the authors noted participants increasingly frequently sitting in pairs or triads, reading and discussing stories. One question on the closing survey asked participants to write an open-ended reflection on new ideas they considered in the workshop. In total, 44 per cent of respondents discussed ideas related to criticality or empathy, often using forceful language to describe their interaction with the stories. For example, one participant wrote, "I enjoyed learning about how interactive fiction can drive people to explore/understand limits and effectively force people to empathize."

Discussion

The design-based research reported in this article yielded fruitful answers to the initial research questions. The first two studies explored the potential uses of interactive storytelling and developed the Web application's affordances to better support participants' aspirations for the medium. Workshop III validated critical discourse models as tools for critical engagement and documented the role of textual and computational affordances. In each workshop, the participants were involved in planning the workshop, framing the questions and interpreting the results. Their participation was essential to the validity of the findings and also to ensuring that the research process could play an equitable role in the literacy spaces which were the focus of study.

This research makes three primary contributions. First, the iterative participatory design process yielded a refined Web application capable of supporting textual-computational multiliteracy in a writer's workshop environment. Development followed (and continues to follow) workshop participants' imagined uses for interactive storytelling, so that the workshops themselves were a critical process of enacting imagined conditions. Unfold Studio has been publicly released and has already been used in several schools, including several months in an introductory computer science course, as well as in a teacher preparation program and professional development workshops focused on computer science and critical literacies. Framing interactive storytelling as an introductory approach to programming may help teachers of computer science view their subject as a literacy, as a resource for their students' existing multi- and transliteracy practices, and as an opportunity to support their students' critical perspectives. The expansion of Unfold Studio as an online literacy space and its efficacy as an introduction to programming are topics of ongoing research (Proctor, 2019).

Second, this research finds theoretical common ground between learning scientists and scholars of critical literacy, and it demonstrates the importance of continued dialogue between these communities. There is substantial overlap between the constructs used by each field to study situated, distributed and mediated meaning-making; this article's framing of literacy spaces may be useful for integrating the perspectives and concerns of each field. This work is particularly urgent given the current emphasis on increasing access to K-12 computer science. Over the past two decades, the computer science education community has devoted increasing

attention to educational equity (Margolis and Fisher, 2003; Margolis *et al.*, 2010; Kafai and Burke, 2013), focusing on unequal participation in computing and factors causing it. This work is important but incomplete. Too often, efforts toward more equitable participation do no critical interrogation of the practices in which they seek to increase participation. There are direct parallels to the decades of work by scholars and practitioners of English/Language Arts grappling with how and when to teach dominant American English. Computing too has a culture of power (Delpit, 1988) and a tendency to view other sense-making practices through a deficit lens (Moll *et al.*, 1992). What might computer science look like if it centered culturally sustaining pedagogy (Paris, 2012), with its insistence on criticality?

Finally, this research yields the concept of critical discourse models, which may be particularly effective in supporting critical awareness in the multi- and transliteracies prevalent in youth culture today. Interactive storytelling offers affordances useful for modeling and analyzing in-person and digitally mediated discourse. Because they make phenomena visible and concrete, critical discourse models may be especially useful in contexts where people have different amounts of experience thinking about these concepts. For example, Unfold Studio was used in a course on literacies in a teacher preparation program where some participants had chosen to become teachers to combat the oppression they experienced on a daily basis. For others who had grown up in privilege, goals of social justice were not grounded in lived experience. These are often particularly difficult settings in which to discuss power and privilege. Those coming from habitual and seldom-questioned privilege may feel they need a nonjudgmental space to consider new self-understandings, and feel threatened by critical positions. However, for people who experience marginalization on a daily basis, the insistence on a safe space which excludes uncomfortable truths can be experienced as an act of erasure by dominant literacy practices. In such a space, interactive storytelling can be used to model experiences such as microaggressions. Those who do not understand how an offhand comment can shatter one's sense of safety and belonging can play and replay an interactive story, empathizing but also coming to understand the mechanisms by which microaggressions can cause harm.

Conclusion

As our society completes its shift from print text to digital media, schools must prepare youth to participate in new forms of literacy. It is clear that computational media do not necessarily lead to the just, peaceful and inclusive social structures imagined by the pioneers of personal and social computing. Indeed, computational media have enabled powerful new forms of surveillance, control and amplification of oppressive ideologies. If we want to support youth in self-authorship, critical agency and participation in designing socio-technical futures, it is imperative that our schools cultivate critical computational literacies which center the lives and identities of the community. The design-based research reported in this article yielded a concrete step toward that goal. As Unfold Studio makes its way into classrooms and writing clubs, future research will continue the project of developing a medium well-suited to supporting critical literacy practices.

Notes

1. There is much more to say about the nature of games, which is not taken up in this article. In the early 2000s, there was a fierce debate between narratologists and ludologists about whether games ought to be analyzed using the machinery of literary criticism. The competing framings of games ran roughly parallel to the representational texts and microworlds presented here.
2. Appendix 1 is available online at <http://chrisproctor.net/research/unfoldstudio>

References

- Aarseth, E. (1997), *Cybertext: Perspectives on Ergodic Literature*, Johns Hopkins University Press, Baltimore, CA.
- Agha, A. (2005), "Voice, footing, enregisterment", *Journal of Linguistic Anthropology*, Vol. 15 No. 1, pp. 38-59.
- Anderson, T. and Shattuck, J. (2012), "Design-based research: a decade of progress in education research?", *Educational Researcher*, Vol. 41 No. 1, pp. 16-25.
- Anthropy, A. (2012), *Rise of the Videogame Zinesters*, Seven Stories Press, New York, NY.
- Anzaldúa, G. (1987), *Borderlands: La Frontera: The New Mestiza*, Aunt Lute Books, San Francisco, CA.
- Bakhtin, M. and Holquist, M. (1981), *The Dialogic Imagination: Four Essays*, University of TX Press, Austin, TX.
- Bang, M. and Vossoughi, S. (2016), "Participatory design research and educational justice: studying learning and relations within social change making", *Cognition and Instruction*, Vol. 34 No. 3, pp. 173-193.
- Barab, S., Thomas, M., Dodge, T., Carteaux, R. and Tuzun, H. (2005), "Making learning fun: quest Atlantis, a game without guns", *Educational Technology Research and Development*, Vol. 53 No. 1, pp. 86-107.
- Bang, M., Medin, D. and Atran, S. (2007), "Cultural mosaics and mental models of nature", *Proceedings of the National Academy of Sciences of the United States of America*, Vol. 104 No. 35, pp. 13868-13874.
- Blikstein, P. (2008), "Travels in Troy with Freire: technology as an agent for emancipation", in Noguera, P. and Torres, C. (Eds), *Social Justice Education for Teachers: Paulo Freire and the Possible Dream*, Sense, Rotterdam, pp. 205-244.
- Blikstein, P. (2014), "Bifocal modeling: Promoting authentic scientific inquiry through exploring and comparing real and ideal systems linked in real-time", in Nijholt, A. (Ed.), *Playful User Interfaces*, Springer, Singapore, pp. 317-352.
- Bogost, I. (2006a), *Unit Operations: An Approach to Videogame Criticism*, MIT Press, Cambridge, MA.
- Bogost, I. (2006b), "Videogames and ideological frames", *Popular Communication*, Vol. 4 No. 3, pp. 165-183.
- Bogost, I. (2007), *Persuasive Games: The Expressive Power of Videogames*, MIT Press, Cambridge, MA.
- Brooke, C. (2009), *Lingua Fracta: Toward a Rhetoric of New Media*, Hampton Press, New York, NY.
- Charmaz, K. (1996), "Grounded theory", in Smith, J., Harré, R. and Van Langenhove, L. (Eds), *Rethinking Methods in Psychology*, Sage, London.
- Cohen, N. (2017), "Silicon Valley is not your friend: Sunday review", *The New York Times*, available at: <https://nyti.ms/2kLUnZP>
- Cole, M. and Engeström, Y. (1993), "A cultural-historical approach to distributed cognition", in Salomon, G. (Ed.), *Distributed Cognitions: Psychological and Educational Considerations*, Cambridge University Press, Cambridge, MA, pp. 1-6.
- Collins, A. and Ferguson, W. (1993), "Epistemic forms and epistemic games: Structures and strategies to guide inquiry", *Educational Psychologist*, Vol. 28 No. 1, pp. 25-42.
- Collins, A. and Greeno, J. (2011), "Situative view of learning", *Learning and Cognition*, Vol. 64.
- diSessa, A. (2001), *Changing Minds: Computers, Learning, and Literacy*, MIT Press, Cambridge, MA.
- Emerson, R., Fretz, R. and Shaw, L. (2011), *Writing Ethnographic Fieldnotes*, University of Chicago Press, Chicago, IL.
- Engelbart, D. (1962), *Augmenting Human Intellect: A Conceptual Framework*, SRI, Menlo Park.
- Fairclough, N. (2004), "Semiotic aspects of social transformation and learning", in Rogers, R. (Ed.), *An Introduction to Critical Discourse Analysis in Education*, Lawrence Erlbaum Associates, Mahwah, NJ, pp. 225-235.

-
- Gee, J. (2004a), "Discourse analysis: What makes it critical", in Rogers, R. (Ed.), *An Introduction to Critical Discourse Analysis in Education*, Routledge, New York, NY, pp. 19-50.
- Gee, J. (2004b), *Situated Language and Learning: A Critique of Traditional Schooling*, Routledge, New York, NY.
- Glassner, A. (2004), *Interactive Storytelling: Techniques for 21st Century Fiction*, AK Peters, Natick.
- Hansen, M. and Hayles, N. (2000), *Embodying Technesis: Technology beyond Writing*, University of MI Press, Ann Arbor, MI.
- Haraway, D. (2006), "A cyborg manifesto: Science, technology, and socialist-feminism in the late 20th century", in Weiss, J., Nolan, J., Hunsinger, J., Trifonas, P. (Eds), *The International Handbook of Virtual Learning Environments*, Springer Netherlands, Dordrecht, pp. 117-158.
- Holland, D., Lachicotte, W., Skinner, D. and Cain, C. (2001), *Identity and Agency in Cultural Worlds*, Harvard University Press, Cambridge, MA.
- Iba, T., Yoshikawa, A. and Munakata, K. (2017), "Philosophy and methodology of clustering in pattern mining: Japanese anthropologist Jiro Kawakita's KJ method", *Proceedings of the 24th Conference on Pattern Languages of Programs, The Hillside Group*, p. 12.
- Inkle (2016), *Ink*, Inkle, London, available at: <https://github.com/inkle/ink>
- K-12 Computer Science Framework (2016), available at: www.k12cs.org
- Kafai, Y. and Burke, Q. (2013), "The social turn in K-12 programming: moving from computational thinking to computational participation", *Proceeding of the 44th ACM Technical Symposium on Computer Science Education - SIGCSE '13, Denver, CO*, p. 603.
- Labrande, H. (2011), "Racontons une histoire ensemble: history and characteristics of French IF", in Jackson-Mead, K. and Wheeler, J. (Eds), *IF Theory Reader*, Transcript on Press, Boston, MA, pp. 389-432.
- Lanier, J. (2010), *You Are Not a Gadget: A Manifesto*, Vintage Books, New York, NY.
- Margolis, J. and Fisher, A. (2003), *Unlocking the Clubhouse: Women in Computing*, MIT Press, Cambridge, MA.
- Markoff, J. (2005), *What the Dormouse Said: How the Sixties Counterculture Shaped the Personal Computer Industry*, Penguin, London.
- Minsky, M. (1988), *Society of Mind*, Simon and Schuster, New York, NY.
- Moll, L.C., Amanti, C., Neff, D. and Gonzalez, N. (1992), "Funds of knowledge for teaching: using a qualitative approach to connect homes and classrooms", *Theory into Practice*, Vol. 31 No. 2, pp. 132-141.
- Montfort, N. (2007), "Generating narrative variation in interactive fiction", doctoral thesis, University of Pennsylvania, Philadelphia.
- Morrell, E. (2015), *Critical Literacy and Urban Youth: Pedagogies of Access, Dissent, and Liberation*, Routledge, New York, NY.
- Murray, J.H. (2017), *Hamlet on the Holodeck: The Future of Narrative in Cyberspace*, MIT Press, Cambridge, MA.
- Nathan, M.J. and Wagner Alibali, M. (2010), "Learning sciences", *Wiley Interdisciplinary Reviews: Cognitive Science*, Vol. 1 No. 3, pp. 329-345.
- Nelson, T.H. (1974), "Computer lib/dream machines".
- NGSS Lead States (2013), *Next Generation Science Standards: For States, by States*, National Academies Press, Washington, DC.
- Norman, D. (1999), "Affordance, conventions, and design", *Interactions*, Vol. 6 No. 3, pp. 38-43.
- Ong, W.J. (2013), *Orality and Literacy*, Routledge, New York, NY.
- Papert, S. (1980), *Mindstorms: Children, Computers, and Powerful Ideas*, Basic Books, New York, NY.
- Paris, D. (2011), *Language across Difference: Ethnicity, Communication, and Youth Identities in Changing Urban Schools*, Cambridge University Press, Cambridge, MA.

-
- Paris, D. (2012), "Culturally sustaining pedagogy: a needed change in stance, terminology, and practice", *Educational Researcher*, Vol. 41 No. 3, pp. 93-97.
- Pea, R. (1985), "Beyond amplification: using the computer to reorganize mental functioning", *Educational Psychologist*, Vol. 20 No. 4, pp. 167-182.
- Pea, R. (1993), "Practices of distributed intelligence and designs for education", in Salomon, G. (Ed.), *Distributed Cognitions: Psychological and Educational Considerations*, Cambridge University Press, Cambridge, MA, pp. 47-87.
- Proctor, C. (2019), "Measuring the computational in computational participation: debugging interactive stories in middle school computer science", *Proceedings of the Thirteenth International Conference on Computer Supported Collaborative Learning, 17-21 June, Lyon*.
- Resnick, M., Maloney, J., Monroy-Hernández, A., Rusk, N., Eastmond, E., Brennan, K., Millner, A., Rosenbaum, E., Silver, J. and Silverman, B. (2009), "Scratch: programming for all", *Communications of the ACM*, Vol. 52 No. 11, pp. 60-67.
- Reyes, A. (2017), *Language, Identity, and Stereotype among Southeast Asian American Youth: The Other Asian*, Routledge, New York, NY.
- Rosa, J. and Burdick, C. (2016), "Language ideologies", *Oxford Handbook of Language and Society*, Oxford University Press, Oxford, pp. 103-123.
- Rosenblatt, L.M. (1968), *Literature as Exploration*, Noble and Noble, New York, NY.
- Ryan, M. (2001), *Narrative as Virtual Reality: Immersion and Interactivity in Literature and Electronic Media*, Johns Hopkins University Press, Baltimore, CA.
- Scribner, S. and Cole, M. (1978), "Literacy without schooling: testing for intellectual effects", *Harvard Educational Review*, Vol. 48 No. 4, pp. 448-461.
- Sipitakiat, A., Blikstein, P. and Cavallo, D. (2004), "GoGo board: augmenting programmable bricks for economically challenged audiences", *Proceedings of the 6th International Conference on Learning Sciences*, pp. 481-488.
- The Design-Based Research Collective (2003), "Design-based research: an emerging paradigm for educational inquiry", *Educational Researcher*, Vol. 32 No. 1, pp. 5-8.
- Lorde, A. (2003), "The master's tools will never dismantle the master's house", *Feminist Postcolonial Theory: A Reader*, pp. 25-27.
- Thomas, S., Joseph, C., Laccetti, J., Mason, B., Mills, S., Perril, S. and Pullinger, K. (2007), "Transliteracy: crossing divides", *First Monday*, Vol. 12 No. 12.
- Vossoughi, S. (2014), "Social analytic artifacts made concrete: a study of learning and political education", *Mind, Culture, and Activity*, Vol. 21 No. 4, pp. 353-373.
- Vossoughi, S. and Gutiérrez, K. (2016), "Critical pedagogy and sociocultural theory", *Power and Privilege in the Learning Sciences: Critical and Sociocultural Theories of Learning*,
- Vygotsky, L. (1980), *Mind in Society: The Development of Higher Psychological Processes*, Harvard University Press, Cambridge, MA.
- Weintrop, D., Beheshti, E., Horn, M., Orton, K., Jona, K., Trouille, L. and Wilensky, U. (2016), "Defining computational thinking for mathematics and science classrooms", *Journal of Science Education and Technology*, Vol. 25 No. 1, pp. 127-147.
- Wilensky, U. (1999), "NetLogo", available at: <http://ccl.northwestern.edu/netlogo>
- Wilensky, U. and Stroup, W. (1999), "Learning through participatory simulations: network-based design for systems learning in classrooms", *Proceedings of the 1999 Conference on Computer Support for Collaborative Learning*, p. 80.
- Wysocki, A. (2004), "Opening new media to writing: openings and justifications", Wysocki, A., Johnson-Eilola, J. and Selfe, C.L. (Eds), *Writing New Media: Theory and Applications for Expanding the Teaching of Composition*, UT State University Press, Logan, pp. 1-23.

Further reading

- Barthes, R. (2010), "From work to text", in Leitch, V. and Cain, W. (Eds), *The Novel: An Anthology of Criticism and Theory, 1900-2000*, Blackwell Publishing, Malden, pp. 236-241.
- Bogost, I. and Losh, E. (2017), "Rhetoric and digital media", in MacDonald, M. (Ed.), *The Oxford Handbook of Rhetorical Studies*, Oxford University Press, Oxford.
- Case, N. (2014), "Coming out simulator", available at: <https://ncase.itch.io/coming-out-simulator-2014>
- Fairclough, N. (1992), "Discourse and text: linguistic and intertextual analysis within discourse analysis", *Discourse and Society*, Vol. 3 No. 2, pp. 193-217.
- Freire, P. (2018), *Pedagogy of the Oppressed*, Bloomsbury Publishing, New York, NY.
- Garcia, A., Mirra, N., Morrell, E., Martinez, A. and Scorza, D. (2015), "The council of youth research: critical literacy and civic agency in the digital age", *Reading and Writing Quarterly*, Vol. 31 No. 2, pp. 151-167.
- Gee, J. (2008), *Social Linguistics and Literacies: Ideology in Discourses*, 3rd ed., Routledge, New York, NY.
- Graff, G. and Birkenstein, C. (2006), *They Say, I Say: The Moves That Matter in Academic Writing*, Norton, New York, NY.
- Inkle Studios (2014), *80 Days*, Inkle Studios, London.
- Koschmann, T., Stahl, G. and Zemel, A. (2004), "The video analyst's manifesto (or the implications of Garfinkel's policies for the development of a program of video analytic research within the learning sciences)", *Proceedings of the 6th International Conference on Learning Sciences*, pp. 278-285.
- Margolis, J. (2008), *Stuck in the Shallow End: Education, Race, and Computing*, MIT Press, Cambridge, MA.
- Meyer, M. (2017), *What Is Rhetoric?*, Oxford University Press, Oxford.
- National Research Council (2000), *How People Learn: Brain, Mind, Experience, and School*, Expanded Edition, National Academies Press, Washington, DC.
- Pea, R. (1994), "Seeing what we build together: distributed multimedia learning environments for transformative communications", *The Journal of the Learning Sciences*, Vol. 3 No. 3, pp. 285-299.
- Proctor, C. and Garcia, A. (2019), "Student voices in the digital hubbub", in Hogg, L. and Stockbridge, K. (Eds), *Giving Student Voice Due Weight: Possibilities and Challenges in USA and New Zealand*,
- Schwartz, D., Chang, J. and Martin, L. (2008), "Instrumentation and innovation in design experiments: taking the turn towards efficiency", *Handbook of Design Research Methods in Education: Innovations in Science, Technology, Engineering, and Mathematics Learning and Teaching*, pp. 47-67.
- Werner, L., Denner, J., Campe, S. and Kawamoto, D.C. (2012), "The fairy performance assessment: measuring computational thinking in middle school", *Proceedings of the 43rd ACM Technical Symposium on Computer Science Education*, ACM, pp. 215-220.

Corresponding author

Chris Proctor can be contacted at: cproctor@stanford.edu

For instructions on how to order reprints of this article, please visit our website:

www.emeraldgrouppublishing.com/licensing/reprints.htm

Or contact us for further details: permissions@emeraldinsight.com