Networked, Information, and Systems as Generative Words:

A Freirean critical pedagogy template

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Abstract: *Introduction to Networked Information Systems* is a course that has been taught by the author since 1997. For much of the time, a participatory action research service-learning component has sought to address the digital divide while supporting hands-on sociotechnical skills development of students and community members. However, extended research on this course has identified key limits in the essential advancement of critical student values development related to the deeper socio-cultural agendas interconnected with digital technologies and the Internet. Unless primed, students often remain centered on problematic political agendas revolving around hyper-individualism, neoliberal capitalism, and technological utopianism. This paper introduces a new teaching template, sans the service-learning component, in which the teacher-student uses "systems", "information", and "network" as generative words, and carefully selected hands-on exercises and digital counter-storytelling as codifications and situation-problems. Through text/context analysis, small group discussions and professional journal reflections, and hands-on activities as innovators-in-use of microcontrollers and computers, student-teachers work to identify and decode these situation-problems. Learning outcomes sought include questioning: who is shaping the design, creation, distribution, selection, and implementation of the many different information and communications technologies we use as a daily part of our personal and professional lives, and for what agendas?; who WE are shaping in our selection, appropriation, and implementation of information and communication technologies within our work as information professionals, and for what agendas?, and; ways to better work as ally's and co-conspirators with the marginalized and oppressed, using their valued functionings as guiding points, to advance individual and community capability sets.

Keywords: Critical Pedagogy; Culturally Sustaining Pedagogy; Information Science Education; Community Informatics Practice; Capability Approach

Introduction

Since the end of the 19th century, the library sciences program in Urbana, Illinois, has fostered innovative research, teaching, and practice in the information sciences. At its beginnings, graduates often served as the first librarians within western towns, serving as "missionaries for culture, for knowledge, for literacy, and the democracy depended on them because democracy depends on an informed population." They were the "world wide web of its time" (Betsy Hearne, "Illinois Innovators: The Women Who Went West", https://youtu.be/8No-dW3tP9w). This work of culture, knowledge, literacy, and an informed citizenry has continued throughout the history of the school now called the School of Information Sciences, the iSchool at the University of Illinois Urbana Champaign.

With the emergence of the telecentre, FreeNet, community network, and CTCNet movements in the late 1980's and early 1990's, the Internet, which at that point was almost exclusively limited to use by University and government researchers, and the newly developing civic networks around the world, began to serve as a major piece in a toolkit facilitating individual and community development goals (Fuchs, 1998; Newby and Bishop, 1996; Schuler, 1996). This included the launch of the Prairienet Community Network initiative at the iSchool in 1994 and for which I began working in 1995. For more than a decade, this Community Informatics initiative worked to foster community inquiry, thereby serving to continue the work of culture, knowledge, literacy, and an informed citizenry, both

in the east-central Illinois community and beyond, with the community, and for the community.

At the same time, a new course primarily for Masters of Library and Information Science students, Introduction to Networked Information Systems, was created at the iSchool. While the primary focus of the course has been on computers and the Internet, it has always recognized that these are but some of the tools within a much larger toolkit fostering individual and community culture, knowledge, and literacy, and an informed and engaged citizenry. To this end, since my first offering of the course in 1997, and as someone centered within Community Informatics, I have struggled to facilitate co-exploration of enrolled students and engaged community within the topics of networks, information, and systems in ways that also recognize the dangers embedded within this course, within the Community Informatics space, and within modern society more broadly. It is too easy to see individual and community development goals, and the challenges in the advancement of agency to achieve the valued beings and doings embedded within those goals, through the specific tools of digital information and communication technologies. The tool becomes the solution to all problems (Stoecker, 2005).

Beginning with the fall, 2000, offering of this course, and continuing through 2015, the course incorporated a service-learning component grounded within participatory action research. Students collaborated with community partners to develop community-defined computer labs, both to address the digital divide and a wider range of community-defined development goals. Throughout, the course sought to advance reciprocal learning through the local knowledge of community residents and professional knowledge within the formal information sciences (Wolske, 2012).

Ongoing research on the course has confirmed the effectiveness to contribute to career development within the information sciences (Nazarova, 2007; An, 2008), but its limits in advancing reciprocal relationships and a higher level of critical thinking (An, 2008). Course learning outcomes development enhancing the personal and political dimensions to foster a more critical reflection of the interaction of technology and society has continued, often through critical dialogical praxis with community members and alums of the course (Wolske, 2012). However, key limits in the essential advancement of critical student values development related to the deeper socio-cultural agendas interconnected with digital technologies and the Internet have been identified. Unless primed, students completing the course in which a service-learning component is incorporated often remain centered on problematic political agendas revolving around hyper-individualism, neoliberal capitalism, and technological utopianism (An, 2008).

This paper, then, seeks to introduce a new teaching template, sans the service-learning component, in which the teacher-student uses "systems", "information", and "network" as generative words, and carefully selected hands-on exercises and digital counter-storytelling as codifications and situation-problems. Through text/context analysis, small group discussions and professional journal reflections, and hands-on activities of a Circuit Playground Express microcontroller and Raspberry Pi microcomputer, student-teachers work to identify and decode these situation-problems. At a time when many non-white males are coached to perform within a fixed mindset in which anything less than perfect is insufficient, and in which in which technology is a source and consequence of gender relationships (Wajcman, 2009), emphasis is placed throughout on student-instructors as innovators-in-use (Bruce, Rubin, and An, 2009) by fostering a fail-forward and growth mindset (Dweck, 1986) and through the raising of critical questions for community informatics in practice (Wolske and Rhinesmith, 2016). Learning outcomes sought include questioning:

- Who is shaping the design, creation, distribution, selection, and implementation of the many different information and communications technologies we use as a daily part of our personal and professional lives, and for what agendas?;
- Who are we shaping in our selection, appropriation, and implementation of information and communication technologies within our work as information professionals, and for what agendas?, and;

- What are some ways we could better work as ally's and co-conspirators with the marginalized and oppressed, using their valued functionings as guiding points, to advance individual and community capability sets.

Course Outline

In 2018, the course description and syllabus were further refined to more clearly outline the course, in part to emphasize the tightly intertwined social and technical aspects of networked information systems, and the structure of the course to explore these deeper socio-cultural agendas within the digital technologies and the Internet while also facilitating a hands-on learning of the nuts and bolts of the technologies themselves. For the first time since the fall, 2000, offering of the course, service-learning was not listed within the syllabus.

The formal course description is as follows:

> This course provides a deep hands-on sociotechnical dive into technology including electronics, software, and networks culminating in a holistic understanding of networked information systems. The course also explores the methodological landscape of networked information systems including theoretical assumptions, research methods, and research techniques. Throughout, students will be introduced to, and make active use of, skillsets, frameworks, and standards employed by a wide range of information professionals in selecting, co-designing, appropriating, and innovating-in-use networked information systems.

As listed in the syllabus, the general learning outcome objectives for the course include:

- **Develop a clear hands-on working understanding of the physical and software layers of computers and networks.** Over the course of the semester, students should develop a growing comfort and competency: working with the basic nuts and bolts of computers and networks; appropriately integrating components to serve as tools for computational and information processing; and performing basic troubleshooting.
- **Evolve a more holistic and nuanced understanding of the sociotechnical artefacts we use as a daily part of our professional lives.** The physical + software + human + social whole that is a digital artefact is greater than the sum of the parts – beyond developing technical competencies, we need to develop an awareness of, and skillsets to influence, the emergent properties that come from specific combinations of the different social and technical building blocks for information systems.
- **Develop a critical approach to sociotechnical artefacts**. Social systems are constructs of economy, politics, matters of race, class, and gender, social institutions, and other cultural dynamics. Design, diffusion, and implementation of technical innovations both reflect and shape these social systems. Critically examining social+technical information systems from multiple individual and societal perspectives opens up consideration of idealized expectations vs. actual positive and negative impacts within specific user communities.
- **Advance community agency in appropriating technology to achieve our individual and community development goals through a reconsidered digital literacy learning and practice.** Far from being just passive adopters of different digital technology artefacts to find, evaluate, create, and communicate information, as Information Science professionals we have opportunities to initiate and lead communities of inquiry, leveraging the plurality of our community's social and technical insights to adapt sociotechnical systems in ways that build a more just and inclusive community.

Course Toolbox

In working through the hands-on activities in the course, a range of electronic components, from individual components like Light Emitting Diodes (LEDs) and switches, to complex circuit boards like the Circuit Playground Express microcontroller and the Raspberry Pi microcomputer are used. There are many variations of these components and the supporting electrical conductors and tools that may shape how students can/should work with various parts to achieve hands-on activities. For this reason, while there are many sources from which these can be purchased, the following have been used for the last three offerings of the course:

- The Raspberry Pi Starter Pack (https://www.adafruit.com/product/3058)
    - The Raspberry Pi 3 microcomputer, Pi 3 Case, Power Adapter, and 8 GB SD Card with Raspbian Linux Operating System
    - Breadboard, Cobbler, a 40-pin Ribbon Cable, and Jumper Wires to provide an electronics prototyping platform that can be connected to the Raspberry Pi
    - A USB to TTL Serial Cable, the old standby for debugging and logging into special purpose devices 'headless', that is, without a keyboard, mouse, and monitor, and that will be used to connect the Raspberry Pi to a personal laptop and to the Circuit Playground Express microcontroller as needed.
    - A package with basic electronic components, including LEDs, Resistors, Potentiometer Variable Resistors, a Capacitor, and a Photo Cell
- The Circuit Playground Express Pack (Individual Kit: https://www.adafruit.com/product/3795; Educator's Pack: https://www.adafruit.com/product/3399)
    - The Circuit Playground Express microcontroller and USB Power Cable
    - Small Alligator Clip Test Leads
    - Multicolor Pack of LED Sequin Integrated Circuits

Over the course of the semester, the mutual shaping of these devices by the Raspberry Pi Foundation, especially highlighting Carrie Anne Philbin, Director of Educator Support, and by Adafruit Industry, especially highlighting Limor "Lady Ada" Fried, founder and owner, are integrated into critical dialogue and reflection. Further, my mutual shaping of the design of the hands-on activities and the guides supporting students implementation of these exercises is considered within this web of mutual shaping. And we work to weekly consider the students own works as innovators-in-use of these kits based on their own mutual shaping of these sociotechnical artefacts.

Course Assignments

The course incorporates quizzes on hardware & electronic tools, core coding concepts, and network tools, grading these using a not-yet/yet, fail-forward multiple attempts learning strategy in which wrong or incomplete answers come with hints and recommendations, and in which students can retake the quiz as many times as desired in advance of the closing of the quiz. Weekly readings, discussions, and journal reflections are used to advance instrumental, practical, and critical thinking skills. And in recognition that technology takes many shapes and forms, that it is capable of both great harm and help, and that it is designed and shaped by humans and thereby shapes the human-analogue experience, the course spends a majority of the semester focused on the implementation of a digital networked information system in support of an existing or imagined analogue networked information system. This co-exploration of digital-analogue-human interactions are facilitated by the use of the class toolbox and related electronic and digital tools; a design challenge using nylon conductive tape, the Circuit Playground Express, and the Raspberry Pi to share digital counter-stories (Strohmayer and Meissner, 2017) about the unknown women and people of colour who have led past and present technology innovations (Cooke, 2017; Lorini, Sabiescu, and Memarovic, 2017); conversations in and outside of the classroom; and by the use of a Little Free Library as a generative theme for considering existing, successful analogue networked information systems and its shaping through team prototypes of digital Little Free Library extensions.

Pedagogical Choices

This course taps into several essential learning theories to advance internal and external cognitive, social and emotional learning and reflection processes in support of sustainable development (Leicht, Heiss, and Byun, 2018). Cognitive learning (Piaget, 1936; Bruner, 1986; Vygotsky, 1978; Papert, 1987) focuses on the ability to logically analyse and organize problems in ways that allow use of digital and other tools to help solve them, and to generalize new processes to other problems. Social and emotional learning (CASEL, 2005), in contrast, focuses on the ability to communicate and collaborate with others, along with the personal confidence, persistence, and tolerance in order to tackle complex, ambiguous, and open-ended problems. Descriptive reflection (describing an activity, task, or event), dialogic reflection (contemplating on the reasons for the activity, task, or event), and critical reflection (investigating the deeper social, ethical, moral or historical contexts shaping the activity, task, or event) enhances problem-solving skills (Cooke and Hensley, 2013). Throughout, the well-established pedagogical tool referred to as failing-forward, building from Carol Dweck's established growth mindset (Dweck, 1986), are used from week one to foster confidence in recognition that many K-12 and higher education spaces instead tend to foster a fixed mindset in ways that especially advantage white males who are instead encouraged to take risks and use creative thinking to serve as innovators in the sciences, technology, engineering, and mathematics.

The best works in a Maker-type environment are works of inquiry by community, in community, and for community. They combine active hands-on innovation with individual and corporate reflection integrating a progressive impulse (Bruce and Eryaman, 2015). To do this, the course works to bring together Collective Leadership (http://theinnovationcenter.org/files/file/Collective-Leadership-ALL-LINKS.pdf; http://www.ethicalleadership.org/uploads/2/6/2/6/26265761/_collective_leadership_framework_workbook.pdf), Community Inquiry (https://chipbruce.net/resources/community-inquiry-bibliography/what-is-community-inquiry/), the Information Search Process (http://wp.comminfo.rutgers.edu/ckuhlthau2/wp-content/uploads/sites/185/2016/02/GI-School-Librarians-in-the-21-Century.pdf), Design Thinking (http://designthinkingforlibraries.com/) and Design for Values (http://designforvalues.tudelft.nl/handbook-of-ethics-values-and-technological-design/), Community Informatics Studio (Wolske, Rhinesmith, and Kumar, 2014), the Pair Programming aspect of Agile Software Development, and Computational Thinking (https://www.iste.org/explore/ArticleDetail?articleid=152).

Extensive work with current and past students of the course, teaching assistants, iSchool student affairs, and the University's Center for Innovation in Teaching and Learning, as well as through research and practice with community partners and professionals in education and Community Informatics spaces, among others, have helped guide the creative, dynamic incorporation of these pedagogical tools and frameworks over the past decade. While for most, these course adaptations have proved extremely useful, there are still some for whom the course is not just a bad fit individually, but is one that needs to be torn apart and rebuilt from scratch. And regardless of the types of feedback given, it remains clear the move from banking system to popular education remains a challenging journey.

In an attempt to tighten the progression of the course and to better integrate exploration of the social + technical whole of the networked information systems used in our daily lives, a new Freirean pedagogical template has been developed, and which is proving very effective in early testing.

A Freirean Pedagogical Template

Incorporated into each of the above teaching and practice frameworks and standards is Critical Pedagogy (Freire, 2011; hooks, 1994) and Critically Relevant/Sustaining Pedagogy (Ladson-Billings, 1995; Osorio, 2018; Yosso, 2006). As noted in Paulo Freire's foundational

text, *Pedagogy of the Oppressed*, this course strives to counter the dominant banking model of education to instead make use of a dialogical, problem-posing educational framework.

For the anti-dialogical banking educator, the question of content simply concerns the program about which he will discourse to his students; and he answers his own question, by organizing his own program. For the dialogical, problem-posing teacher-student, the program content of education is neither a gift nor an imposition—bits of information to be deposited in the students—but rather the organized, systematized, and developed "re-presentation" to individuals of the things about which they want to know more. Authentic education is not carried on by "A" for "B" or by "A" about "B," but rather by "A" with "B," mediated by the world—a world which impresses and challenges both parties, giving rise to views or opinions about it. These views, impregnated with anxieties, doubts, hopes, or hopelessness, imply significant themes on the basis of which the program content of education can be built. (Page 93, 30th Anniversary Edition)

For Freire, generative words are words that contain syllables that can be separated and recombined to form other words. But in addition, such generative words can further be incorporated into generative themes. Freire specifically used the term generative to indicate that these words and the broader themes in which they are incorporated, however comprehended and however used by student-teachers, contain possibilities for leading the co-explorers to new creative tasks calling for fulfillment.

Within Introduction to Networked Information Systems, the course now progressively works through three Units in which the generative words "system", "information", and finally "network", are individually introduced. The course also uses a design challenge to bring forward the generative theme "networked information systems" to be explored.

Generative words and themes lead co-explorers into identification of the limit-situations built through domination. For Freire, domination implies its opposite, limit-acts leading to the objective of liberation. Instructors build up a codification, or picture, of the key terms and embedded components within the generative words and themes. Groups then work to step away from the situation to look at the overall picture to identify with aspects of the limit-situations so as to bring the picture into clearer focus. From this, the terms are recodified, thereby creating a new world, starting a new cycle of action-reflection praxis.

 To foster this co-exploration within Introduction to Networked Information Systems, each Unit of the course begins with an initial exploration of the formal definitions and use of key words and concepts related to its generative word. Using problem-posing education, this introduction to the normative codification of each of these foundational generative words, along with selected readings of text and context and hands-on exercises with the technologies within the toolkit, are used to lead the student-teachers into works to decodification and recodifidication these definitions and use of the key words within the larger generative word.

Dialogue is the other distinctive feature of a Freirean pedagogical template. It is the I-thou relationship between two subjects (Freire, 2011, pg 185). The instructor-student and student-instructors come together as knowledgeable equals joining together in co-exploration and two-way communication. While the teacher-student may possess specific unique topical knowledge related to the specific learning outcome objectives, the student-teacher possesses culturally relevant and sustaining wealth and knowledge based on their unique lived experiences. As a Freirean educator brings together problem-posing education with dialogue, a vibrant action-reflection praxis is implemented.

By bringing this Freirean pedagogical template into the broader combination of pedagogical tools, and frameworks, some of which themselves incorporate critical pedagogy,

the course is tightened to even more fully achieve goals to radically transform education from the unacceptable work as bankers transmitting knowledge to the empty-vessel student. Instead, it is further becoming a work of revolutionary leadership, a work of liberation that includes both denouncement and critique of existing systems and pronouncement and creation of new, transformative models. To achieve this, Freire notes "A revolutionary leadership must accordingly practice *co-intentional* education. Teachers and students (leadership and people), co-intent on reality, are both Subjects, not only in the task of unveiling that reality, and thereby coming to know it critically, but in the task of re-creating that knowledge. As they attain this knowledge of reality through common reflection and action, they discover themselves as its permanent re-creators. In this way, the presence of the oppressed in the struggle for their liberation will be what it should be: not pseudo-participation but committed involvement. (Freire, 2011, pg 67)"

It is important to note that the work of the revolutionary leader does not remove from them the work of directiveness entirely. Moving away from the banking model of education does not mean to enter into a laissez-faire pedagogy, as this heightens the risk that the educator will inadvertently influence or coerce students to follow the instructor's non-neutral stance and to ultimately maintain the existing authoritarian status quo. Rather, the challenge is to use the authoritative (as opposed to authoritarian) expertise of the instructor within their specific domains to construct effective course content that can then be used to connect the activities of the course with the outside world. The difficulty is to do this in a way that does not interfere in the agency of the participants to use their own creativity and lived experiences as a part of the formulative and investigative dialogic praxis within the classroom. The classic components of learning tasks and outcomes, of accountability, and a specified range of acceptable areas of focus within a designated course of learning remain within a Freirean pedagogy. Finding that in-the-moment sweet spot between directiveness and dialogue is the rarely precise, never-ending challenge when "in pursuit of a *true* problem-posing education (Chambers, pg 42; emphasis in original).

The Freirean Template in Practice

Below is the general outline used to create the separate units for the course Introduction to Networked Information Systems. Rather than providing a separate list of weekly social and technical readings, hands-on activities, and assignments using a course Moodle (the free and open-source learning management system used by the iSchool), as was done in previous semesters, a new Creative Commons remixable platform is being used. In this way, the instructor-student and student-instructors have greater clarity as to the specific problem-posing framing of a unit, as well as greater flexibility to dynamically restructure the course using the diverse knowledge and community cultural wealth brought forward through each member of the collaborative. An eText format is being used in which commenting, failing-forward testing, and remixing can occur in a course-specific environment, with these works

being then incorporated into an open-education edition accessible globally as all are released using Creative Commons licensing to foster creative remixing[1].

Unit Components

- Problem-posing framing: Unit's overview theme & key learning outcomes
- Codification: technical praxis to build up a picture
- Decodification: social praxis to begin identifying with aspects of the situation, find themselves in that situation, and ability to reflect critically upon the aspects to bring picture into new focus.
- Recodification: a Design Challenge associated with the word or a combination of these words to creatively bring new lens on picture into consideration as part of a design process, with emphasis on process as much and more as product.

Unit Table

Unit Overview: *problem-posing title* Generative word: *word*		
Session	**Social**	**Technical**
1	*Chapter Title*	*Chapter Title*
2	*Chapter Title*	*Chapter Title*
3	*Chapter Title*	*Chapter Title*
4	*Chapter Title*	*Chapter Title*
Unit End Notes: Definitions, Resources, and References		

Using this starting template of components and table, the following three units were created: the orange unit with a focus on technical "systems", from basic electronic components to general building blocks; the blue unit with a focus on "information" collection

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[1] The University of Illinois eText (https://etext.illinois.edu/) is being used to create a Creative Commons edition that is only accessible to students in the current class. Feedback from students will be continuously used to create new open editions of the course text developed as part of the Publishing Without Walls project (https://iopn.library.illinois.edu/publishing-without-walls/) and the Illinois Open Publishing Network (https://iopn.library.illinois.edu/). Early drafts of new and revised chapters can be found at the author's personal website (http://apcg.wolske.site/).

using microcontrollers and breadboards, and sharing of information and stories using microcomputers; and the rainbow unit with a focus on "networks", from analog to digital, and local to global.

This template is being implemented using the flowing overall table of contents:

Orange Unit Overview: A Person-Centered Demystification Launch Generative word: Systems		
Session	**Social**	**Technical**
1	Introduction to the Course	Introduction to Electronics
2	A Critical Social + Technical Perspective	Electronic Components in Series
3	The Unknown Tech Pioneers, Past & Present	PyPi-Controlled LEDs Using Switches
4	Hidden Innovators Counter-story Design Challenge	Computer Building Blocks
Orange Unit End Notes: Definitions, Resources, and References		

Blue Unit Overview: Computational Tinkering Generative word: Information		
Session	**Social**	**Technical**
1	The Journeys of Hardware and Programming Logic	Essential Coding Concepts
2	The Methodological Landscape	Building a Toolbox Trumpet
3	Community, Cultural, Wealth, Pedagogy	A 4 Octave Trumpet Using Push Buttons variables and functions
4	Valued, Inclusive Information and Computing Technology Experiences	The Raspberry Pi Counter-Story Little Free Library
Blue Unit End Notes: Definitions, Resources, and References		

Design Challenge #2: Little Free Library Digital Networked Information System Extension Generative Theme: Networked Information Systems

Rainbow Unit: Networks Big & Small Generative word: Networks		
Session	**Social**	**Technical**
1	Medium of choice, Meta-Design, Critical Incidents Analysis	Raspberry Pi Apache and MySQL Server
2	The Knowledge Age	The Raspberry Pi Counter-Story Little Free Library
3	More on Community Networking, Commercial Internet	More on Ethernet
4	More on IoT, Smart Cities & Smart Devices	More on Internet Protocols
Rainbow Unit End Notes: Definitions, Resources, and References		

Conclusion

This template builds from two decades of networked information systems popular education, and the associated exploration of ways to facilitate the progressive asking of better questions through failing forward in collaborative action-reflection praxis. This work has focused increasingly on a person-centered approach to demystifying technology and the adoption of a counter-storytelling model to bring forward the concealed, resistance, and emerging/transformative stories within sociotechnical artifacts. As such, the template represents a new formalization of these practices rather than a major change of the course itself. Through a clearer representation of the components, the use of this template is providing a clearer path for the student-instructors to join into a community of practice: learning about core concepts and terms used to design, build, and implement the networked information systems around us; discovering ways to more effectively select, use, and innovate-in-use these systems; and entering into a lifelong transformation of our personal and collaborative ethical community informatics praxis. Rather than serving exclusively as a template for a specific offering of a specific course, this template further seeks to serve as both a starting point and also a space for remixing of praxis as related to networked information systems specifically, and its application within the realms of community informatics, community engagement, community archiving, development informatics, and related spaces. This paper seeks to serve as a next step for further critique and refinement of these materials, and their application within a growing range of professional contexts.

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