The Network and the Classroom:
A History of Hypermedia Learning Environments

by
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Abstract

Hypermedia tools for organizing knowledge have long been designed to benefit how people think, learn, collaborate, and generate ideas. Contemporary iterations of these types of "tools for thought" build upon both technology and pedagogy that has been developing since the early days of personal computers. However, despite a multi-decade history of the development of hypermedia knowledge organization tools both within and outside of educational contexts, we see little transformation of the classroom connected to these types of tools today. In this thesis, I argue that examining the history of hypermedia knowledge organization tools by looking at both successful and failed experiments in bringing them into classrooms, one can more deeply understand the conceptual origins of the recent generation of networked knowledge tools and how to avoid challenges that have plagued them in the past when considering where they might fit into today's classrooms.

Looking across three distinctly different time periods, I examine technical, cultural, and pedagogical shifts that contributed to the changing designs and classroom applications of these tools. I develop a case study describing one application of contemporary hypermedia knowledge organization tools in a middle-school classroom during the Fall of 2020. This case study, a project called "Learning Dens," builds upon lessons from the previously examined eras, and draws inspiration from contemporary uses of hypermedia knowledge organization tools outside of the classroom for sharing in-progress collections of ideas. Set against the backdrop of the COVID-19 pandemic, this case explores using hypermedia knowledge organization tools in the classroom to support social-emotional learning and reflection.

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Table of Contents

Acknowledgements

Introduction

Throughout the history of computing, there has been a long-standing belief that computer-based systems can be designed both to *replicate* and *extend* how people internalize and organize knowledge. Indeed, this notion is often used to suggest that engaging with such systems might benefit how people learn and think. Andy Matuschak and Michael Nielsen refer to this belief as a "founding myth" of modern computing, the idea that computer-based tools would augment the human intellect at large, even changing the thought patterns of human civilization as a whole.[1] This idealistic language, which has been used to articulate the relationship between computers and processes of thinking and learning, accompanied the growth and development of personal computing through the twentieth century, from Douglas Engelbart's foundational design report on "augmenting human intellect" in 1962, to Steve Jobs' now-famous description of personal computers as "a bicycle for our minds."[2]

Moving from this "founding myth" to the present, there has been a recent explosion in popularity of new digital tools for creating systems to organize and share knowledge which align with this early ethos and rhetoric of the "thought-augmenting" computer. Many of these self-described "tools for thought" promise to positively affect how people think, learn, and generate ideas. These contemporary tools make claims of helping people develop their own "second

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[1]Andy Matuschak et al., "How Can We Develop Transformative Tools for Thought?," 2019, https://numinous.productions/ttft.

[2] Douglas C. Engelbart, "Augmenting Human Intellect: A Conceptual Framework," *Menlo Park, CA*, 1962; Michael Lawrence, *Steve Jobs, "Computers Are like a Bicycle for Our Minds." - Michael Lawrence Films*, 2006, https://www.youtube.com/watch?v=ob_GX50Za6c.

brain" by creating and following connections between notes and ideas *(Example 1)*. They emphasize non-linear notetaking and knowledge organizing, and often use imagery and user interfaces that incorporate interconnected nodes of ideas *(Example 2)*. They offer opportunities for collaboration and connection-making across contexts *(Example 3)*. And finally, they propose that deeper learning can occur in these shared knowledge organizing spaces *(Example 4)*.
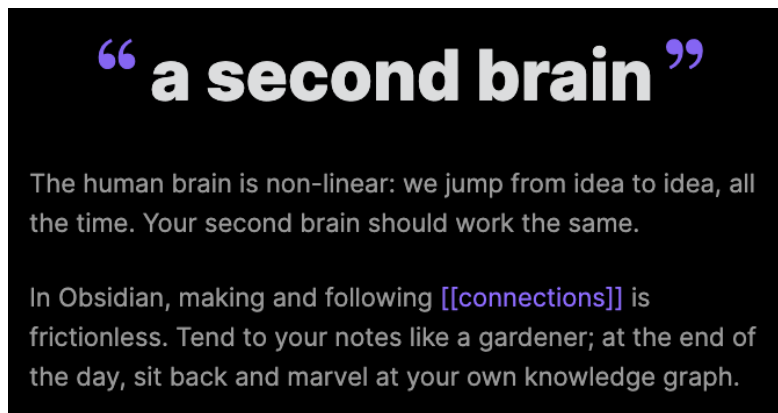
Example 1: Obsidian [3]
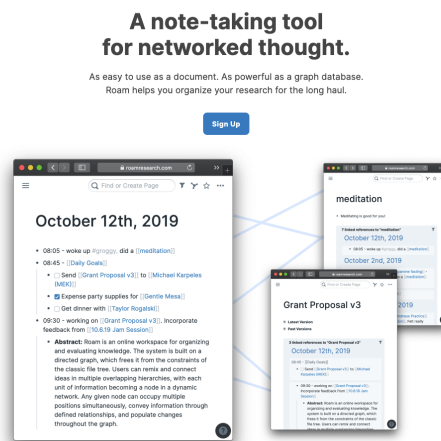
Example 2: Roam Research [4]

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[3] "Obsidian: A Knowledge Base That Works on Local Markdown Files.," accessed April 5, 2021, https://obsidian.md/.

[4] "Roam Research – A Note Taking Tool for Networked Thought.," accessed April 5, 2021, https://roamresearch.com/.

Example 3: Are.na [5]

Example 4: Remnote [6]

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[5] "Are.na," accessed April 5, 2021, https://www.are.na/.

[6] "RemNote | The Best Way to Remember and Organize What You Learn," accessed May 5, 2021, https://www.remnote.io/.

While these recent tools make lofty claims about their new features which are designed as digital environments to benefit thinking and learning, they build upon both technology and pedagogy that has been developing since the early days of personal computers. Many ideas regarding the connections between computers, learning, and the nature of knowledge were first articulated in the mid-twentieth century by the early progenitors of *hypertext* and *hypermedia* – systems for non-linearly and non-hierarchically organizing and navigating through media forms. At its most simple, *hypertext* is text displayed on a computer that contains references or "links" to other text which the reader can click to follow, to leap to that other text. Ted Nelson, the information technologist and philosopher who coined the term in 1963, describes hypertext as "a body of written or pictorial material interconnected in such a complex way that it could not conveniently be presented or represented on paper."[7] A hypertext document can contain many interconnected hyperlinks, meaning that information can be organized and accessed non-linearly, and instead allow a user to choose their own paths to follow. Relatedly, *hypermedia* refers to other forms of media that can connect in the same way, "meaning complexes of branching and responding graphics, movies and sound – as well as text."[8] Many aspects of the early hypertext and hypermedia designs became fundamentally influential for the computational systems that today's computer-users are familiar with, as the functions of hypermedia are the basis of how the Internet is structured and navigated.

Looking across this collection of new hypermedia tools with overlapping design decisions and intentions, how might one refer to this genre of tool to frame its current landscape

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[7] Theodor H. Nelson, "Complex Information Processing: A File Structure for the Complex, the Changing and the Indeterminate," in *Proceedings of the 1965 20th National Conference*, 1965, 84–100.

[8] Theodor H. Nelson, "Literary Machines: The Report On, And Of, Project Xanadu, Concerning Word Processing, Electronic Publishing, Hypertext, Thinkertoys, Tomorrow's Intellectual Revolution, And Certain Other Topics Including Knowledge, Education And Freedom," 1981.

and lineage? Many of these tools have been described as "networked note-taking systems," "non-linear notebooks," or as part of the broader category of "tools for thought." Looking at these tools as a group, I broadly classify this genre of tool as *Hypermedia Knowledge Organization Tools*, a term that I will use throughout this thesis. I add the *Knowledge Organization* descriptor because this specific genre of tools prioritizes enabling users to actively input, structure, and organize knowledge into a hypermedia system, rather than platforms where users engage with pre-designed experiences.

Hypermedia Knowledge Organization and Learning

Despite this history of hypermedia knowledge organization tools which have long been promised to offer learning benefits, we see little transformation of the classroom connected to these types of tools today. Why is this? Can or should we seek to change that? How can classrooms use these emerging systems for collaboratively sharing and organizing knowledge to benefit learners? And how can we learn from the past to better shape the future of this work? In this thesis, I argue that examining the history of hypermedia knowledge organization tools by looking at both successful and failed experiments in bringing them into classrooms, one can more deeply understand both the conceptual origins of these recent networked knowledge tools and consider where they might be able to fit into today's classrooms and how to avoid challenges that have plagued them in the past.

At first glance, developing learning practices that incorporate these tools might seem to be a natural fit within the contemporary moment in which we find learners spending ever-increasing time with digital tools throughout their lives. Framed in this context, building new capacities to document, organize, and structure knowledge is recognized as crucial 21st century

skills which becomes ever-more relevant when encountering increasing information saturation and time spent on the internet.[9] Of course, regardless of whether these tools appear naturally fit to provide educational benefits, making changes to education broadly is undoubtedly a challenging task. Particularly in the context of educational technology, new tools with great promise come in and out of popularity quite regularly, and very rarely make any significant changes in popular educational discourse.[10]

In his book "Failure to Disrupt: Why Technology Alone Can't Transform Education," Justin Reich talks in depth about why many of the technologies which have been promised will radically transform educational practices have failed. Drawing on Morgan Ames' framework for technological utopianism in "The Charisma Machine," Reich sets forth a juxtaposition between two stances: the charismatic stance, and the tinkering stance. The *charismatic* stance typically accompanies technological "innovation" – it is the notion that the technology inherently will offer wholesale transformation of existing systems. In comparison, the tinkering stance, he says, "sees schools and universities as complex systems that can be improved, but they believe that major improvement is the product of many years of incremental changes to existing institutions rather than the result of one stroke of wholesale renewal."[11] Throughout this thesis, I take a tinkerer's stance both to examine the history and consider the possible value of these types of tools. This tinkerer's stance is an approach to drawing lessons from the early and failed experiments with hypermedia knowledge organization tools for learning and builds upon this

[9] Helen Soulé and Tatyana Warrick, "Defining 21st Century Readiness for All Students: What We Know and How to Get There.," *Psychology of Aesthetics, Creativity, and the Arts* 9, no. 2 (2015): 178;
Tara Zimmerman, "Information Overload & Its Effect on High School Students," Paper, 14th International Conference on Knowledge Management, November 9-10, 2018. Vancouver, Canada., November 9, 2018, https://digital.library.unt.edu/ark:/67531/metadc1393764/.
[10] Dean R. Spitzer, "Why Educational Technology Has Failed," *Educational Technology* 27, no. 9 (1987): 18–21.
[11] Justin Reich, *Failure to Disrupt: Why Technology Alone Can't Transform Education* (Harvard University Press, 2020), 10.

history to consider how contemporary iterations of these tools in the appropriate context might be able to offer some incremental changes to classrooms.

Chapter Structure

This thesis examines three distinctly different moments of rapid emergence of these hypermedia knowledge organization tools. The first moment is a five-year period from 1983-1988, where several hypermedia-based applications were designed to enhance learning and were used in a variety of educational contexts. This section will examine the technical and cultural conditions which set the stage for this new set of tools, including expanded capacities for networked computing, advances the display of graphical user interfaces, and new models of learning and cognition. A close reading of three of these tools, the way they were designed, and examples of their use in and out of the classroom will elucidate the beliefs about thinking and learning that these tools embodied. This section will also address why, despite their lofty goals, the tools created during this period failed to fundamentally alter educational practices.

The second moment is a period of excitement that occurred in the wake of the popularization of Web 2.0 technologies and design methodologies from 2004 roughly until 2010, which were focused on building web-based tools that were interactive and social. At this point, there was significant experimentation with *wikis* as collaborative learning and research tools in classrooms of a wide variety of subject areas and degrees of expertise. Wikis are a type of collaboratively editable hypertext publication that is accessible using the web browser, most familiar with websites like Wikipedia. This chapter will examine research regarding learning activities that were conducted using wikis and discuss the types of collaborative behaviors that educators designed when using wiki platforms. Investigating both the design of wikis as well as the ways that they were employed in classrooms, this chapter argues that there were distinct

aspects of the wikis design, as well as specific ways that wikis were used in classrooms that together led to its inability to be widely adopted.

The third moment is the contemporary 5-year period from 2016 to 2021. The hypermedia learning tools developed in this moment notably shift away from hyper-specialized tools for thought which are explicitly designed for the classroom, and towards informal learning and classroom-adjacent spaces. While the tools and strategies emerging during this moment resemble aspects of the tools created during the mid-80s, they explicitly draw upon (and reject) other design conventions that have been established in the past decade's explosion of social media. The design of these recent tools and practices also pushes for creating small collaborative networks.

In this section, I also develop a case study describing one application of contemporary hypermedia knowledge organization tools used in a middle-school classroom during the Fall of 2020. This case study, called "Learning Dens" builds upon lessons from the previously examined eras, and draws inspiration from contemporary uses of hypermedia knowledge organization tools outside of the classroom for sharing in-progress collections of ideas. Set against the backdrop of the COVID-19 pandemic, this case explores using Hypermedia Knowledge Organization tools in the classroom in the context of supporting social-emotional learning during a time of distance learning.

Upon close examination of this current landscape and its history, it becomes clear that there is a circularity to the ideas that underlie these tools. An emphasis on creating connections, encouraging ideas to live in multiple contexts, and supporting interdisciplinary collaboration carry through the designs of these tools, as well as the classroom practices that they were employed within. However, closely studying the different interactions that are prioritized across

the set of tools from each of these moments, examining their successful and failed applications in

the classroom, and framing them within contexts of technological and pedagogical change, can

frame the beginnings of a design vocabulary for situating hypermedia knowledge organization

tools in classrooms. Such a vocabulary can be used to understand and evaluate the design of

future hypermedia thinking and learning tools, and to begin to imagine ways that these types of

tools can be used effectively both inside and outside of classrooms.

Foundations of Hypermedia Learning

1.1 Introduction

The notion that learning occurs through the process of forming connections between ideas persists across all levels and scales of learning. Indeed, descriptions of "connection-forming" as learning can be found in accounts of the biological processes of forming synaptic connections in the brain all the way up to the conceptual level of connecting ideas to form new knowledge and understanding. Early hypertext and hypermedia platforms attempted to externalize and formalize this metaphor by allowing users to create and follow chains of connections between ideas as represented through multimedia forms. At the heart of early theorizations of hypertext and hypermedia systems was the belief that creating external tools to augment this seemingly innate human capacity to make meaningful connections between ideas could amplify human learning processes.

Though this belief in the power of hypermedia to accelerate learning remained dormant for decades, by the mid-1980s, multiple hypermedia platforms simultaneously sprung forth that were specifically designed for the educational context. Researchers from across educational and commercial institutions promised that hypermedia-oriented learning tools would offer learners newer and faster ways of accessing knowledge, new modes of collaboration, and new types of interactions to enable learners to forge connections between ideas. Researchers and designers alike proposed that the hypermedia tools which they were designing to accompany rapid advances in computing would change how learners learn, how teachers teach, and how

classrooms were structured. What was in the air at that moment that brought multiple hypermedia tools into existence in such synchrony? How did each of these tools implicitly offer a vision for the future of education?

In this chapter I argue that there are three main drivers of change which contributed to the development of computationally imbued educational tools in the mid-1980s. The first driver is a set of preconceptions about the connections between hypertext and learning that had been embedded in the language around hypertext and hypermedia since its origins in the 1940s. This chapter will begin by briefly looking at early examples of pre-digital and imaginary hypertext systems that set forth some of the initial ideas about the relationship between learning and generating associative links between ideas. This will touch upon Vannevar Bush's Memex, an imagined research tool from 1945 which set the stage for much of modern computing. Bush's description of this tool implicitly sets forth several propositions about how computers could aid research and learning practices by allowing users to make and store associations between information.

The second driver involved using new understandings of how people learn to inform the development of computational systems which were designed to make use of how the brain was known to work. In the 1980s, this included new trends in educational psychology and learning sciences, which offered new models for learning and cognition. A third key aspect in the development of hypermedia learning tools in this moment was a wave of technological advancements which enabled new types of experimentation in the development of curriculum and instructional tools. By the mid-1980s, significant developments in storage, computing power, graphical representation, and networkability afforded new modes of learner interactions with computers. It is in this moment where one can see a confluence of learning theories which

describe the collaborative and social nature of learning, theories describing knowledge integration using hypertext metaphors, and simultaneously when computers suddenly had the capacity for networked collaboration.

After discussing these three crucial factors in the development of these tools we will turn to three examples of the hypermedia learning tools that emerged from this confluence of conditions. Examining these instantiations of hypermedia learning tools will illuminate not only the beliefs about the relationships between computers and learning at the time, but notions of how schools of the future would operate.

1.2 Hypermedia and Learning: Preconditions

Any account of the history of hypertext tends to begin with Vannevar Bush. An American engineer and inventor, Bush led the U.S. office of Scientific Research and Development throughout World War II. Following the war, Bush sought to imagine tools which might enable the human mind to think and learn across disciplines more readily. In part, this stemmed from a fear that the increasing hyperspecialization which he saw amongst his research organizations would lead to a mountain of inaccessible knowledge that would stifle post-war progress. In his 1945 piece in the Atlantic titled "As We May Think," Bush proposed a device called the Memex to deal with this challenge. The Memex was a device which would hold microfilm copies of a user's personal library and would allow them to make automatic connections between text, such that they could create chains of intertextual association. Users of the Memex device, which he imagined could be people of all varieties of professions, could save and share these paths of ideas between texts, as well as their notes about them.

As is apparent in the title of his piece, Vannevar Bush wanted to develop a device that operates as, he believed, *we may think.* This notion that the mind naturally operates by association carries throughout this entire text, as he says: "with one item in its grasp, [the brain] snaps instantly to the next that is suggested by association of thoughts, in accordance with some intricate web of trails carried by cells of the brain."[12] Furthermore, Bush believed in the usefulness of this tool not only for forming one's own personal connection and paths of thoughts, but for sharing and collaborating on them. He even imagined an entire "new profession of trail blazers, those who find delight in the task of establishing useful trails through the enormous mass of the common record. The inheritance from the master becomes, not only his additions to the world's record, but for his disciples the entire scaffolding by which they were erected."[13]

There are three presuppositions embedded in Vannevar Bush's optimistic vision for the Memex as a learning and thinking tool. These conjectures, I argue, extend as justifications for the grand visions about the usefulness of hypermedia for education more broadly.

Conjecture 1: First, is the idea that the mind naturally thinks and learns by making **associations**. Individual ideas are connected to each other, and that it is in our nature to form connections and linkages between ideas.

Conjecture 2: Associations between ideas can link together from one to the next to form **trails** of connection, as Bush describes. Developing tools by which one can create and save these trails will allow for deeper learning.

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[12]Vannevar Bush, "As We May Think," The Atlantic, July 1, 1945,
https://www.theatlantic.com/magazine/archive/1945/07/as-we-may-think/303881/.
[13] Vannevar Bush, "As We May Think."

Conjecture 3: These trails are meaningful chunks of knowledge which can be built **collaboratively**, passed from one person to the next, and extended in various directions based on context.

These three threads carry on as implicit design justifications for using hypermedia as learning and research tools. In the decades that followed Bush's initial formulation of the Memex, new pedagogical models, theories of cognition, and emerging technologies connect back to these points, naturalizing hypertext as an extension of existing human thought processes and justifying new models for collaboration and knowledge construction.

1.3 Computing Developments

New developments in computing were essential in creating the conditions for educational hypertext experiences to develop. In 1981, IBM released its first personal computer, the first computer to gain massive industry adoption. The same year, France Telecom offered its Mintel terminals, the largest online service before the world wide web. By 1982, LAN operating systems emerged, allowing networked links between computers in offices. In 1983, Microsoft introduced Word, and by 1984, the CD-ROM exploded in popularity just as Apple released the Macintosh with its infamous Orwellian advertisement. By 1985, commercial computers had become powerful enough to store and manipulate multimedia content just as computer networking practices were becoming increasingly popular and in the business sector.

Another important development in computing during the early 1980s was the ability to present graphical information on computer screens, rather than engaging with computers primarily through a command line interface. The development of a common design language around graphical user interfaces (or GUIs) brought the emergence of visual metaphors that

became the standard for communicating with computers, the notion of a "mouse cursor" controlled by a user, and windows, icons, and menus. GUIs had been experimented with on computers since the early 1970s, primarily in Xerox PARC, which developed the Alto personal computer, the first to use the desktop metaphor. However, while GUIs had been in development on and available on non-commercial products throughout the 1970s, by the early 1980s commercial computers began to offer graphical user interfaces and soon became a norm. Apple's 1979 computer the Apple Lisa, which was released in 1983, was one of the early commercial computers which offered graphical user interfaces and allowed for basic multitasking across windows. It was soon followed by the Macintosh computer in 1984, which became the first largely commercially successful product to use the "window" metaphor.

Computers that offered graphical user interfaces that employed the "window" metaphor became incredibly foundational for the development of hypermedia tools; being able to represent multiple documents simultaneously and forging connections between them requires a substantial degree of visual information that cannot be expressed using linear text. Furthermore, the GUI also enabled computers of this era to display images, which opened possibilities for developing *hypermedia* systems, rather than working with hyper*text* alone.

1.4 Schema Theory and Computational Metaphors in the 1970s-80s

By the mid-twentieth century, new theories of knowledge acquisition began to describe learning and thinking as processes using computational and diagrammatic metaphors which sounded much like Ted Nelson and Vannevar Bush's early descriptions of hypertext systems. These perspectives on learning were foundational in bridging the language of hypertext to the language of learning, which deeply informed the educational hypermedia tools to come. One

model of learning that stands out for its overlap with hypertext vocabulary is the model of schemas, a concept from psychology and cognitive science which describes patterns of thought or behavior which organize information and the relationships between them.

Contemporary research on schemas began with F. Bartlett in 1932, whose research examined the role of prior knowledge in the interpretations in retelling of stories. In one set of research studies, participants were told a traditional Native American story about ghosts and were asked to retell the tale. As participants were called back to retell the story over time Bartlett noted systematic changes in the participants' depending on their cultural backgrounds, shifting details about the story that they did not understand to fit their own cultural frame. Based on this research, Bartlett claimed that memory is a process of reconstruction, and one which is reliant on pre-existing social and cultural factors. Bartlett used this research to develop the theory of schemas, a high-level structure of concepts which organize prior experiences, and interpret and learn from new ones. Schemas were proposed to offer frameworks for rapidly processing information about one's environment. Furthermore, this idea implied that there could be situations where individuals experience similar situations, but would not lead to identical knowledge acquisition, a proposition at odds with behaviorism.[14]

By the late 1970s, scholars returned to Bartlett's notions of the schema in part due to a general dissatisfaction with behaviorist approaches to knowledge acquisition when trying to develop artificial intelligence machines. These newer schema theories drew on computational metaphors for describing knowledge acquisition, thinking about knowledge as being stored like data in structured memory. In 1977, for example, Ortony and Rumlhart wrote about schemata as "data structures for representing the generic concepts stored in memory...the network of

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[14] Ralph E. Reynolds, Gale M. Sinatra, and Tamara L. Jetton, "Views of Knowledge Acquisition and Representation: A Continuum from Experience Centered to Mind..," *Educational Psychologist*, June 8, 2010, 97.

interrelations that is believed to generally hold among the constituents of the concept in question."[15] These schemas have attributes which they share and overlap with other schemas, like miniature networks which form cohesive conceptual units from interrelated elements and attributes of knowledge.[16]

The model of the schema involves considering mental constructs as individual "schemata," which together form schema through associative structures which consist of attributes and relationships. Schemas are described as being embedded one within another, representing knowledge across all levels of abstraction. These descriptions draw immediate parallels to early descriptions of hypertext. When considering the possibilities for hypertext as a tool for instructional design, David Jonassen suggests that "hypertext can function as a model of schema theory, with each node comprising a schema that is associated (linked) with other nodes in an associative structure."[17] Using these metaphors, the schema model of knowledge acquisition supported notions of hypertext systems as tools which mirrored the brain's own processes, and in doing so could be used to model, extend, and share one's own knowledge.

1.5 Social Constructivism

In 1978, post-revolutionary Soviet psychologist Lev Vygotsky's book *Mind in Society* was published in English, forty-six years after his death. This book brought a renewed popularity to the sociological theory of knowledge called social constructivism, which incorporates ideas

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[15] Andrew Ortony and David E. Rumelhart, "The Representation of Knowledge in Memory," *Schooling and the Acquisition of Knowledge*, 1977, 99.

[16] David H. Jonassen, "Representing the Expert's Knowledge in Hypertext," *Impact Assessment* 9, no. 1–2 (June 1, 1991), 97.

[17] David H. Jonassen, "Hypertext as Instructional Design," *Educational Technology Research and Development* 39, no. 1 (March 1, 1991), 86.

about knowledge, learning, and development that challenged behaviorist ideas of knowledge

construction. Social constructivism emphasizes the deeply collaborative nature of learning,

suggesting that knowledge develops through how people interact with each other, their culture,

and society at large. In classroom learning, students rely on others to help create their own

building blocks with which they incorporate new ideas and interpret their existing assumptions

about reality.

Vygotsky argued that the cognitivists had misunderstood the collaborative process of

learning, distinguishing between the level of "actual" development (or the level of development

that the learner has already reached and capable of independently solving problems) and the level

of "potential" development, which is the level of development that the learner can reach with

guidance from educators and through peer collaboration. He suggested that through

collaboration, the learner can grasp material at the level of potential development that they would

not be able to do independently, and it is at this level that learning takes place.[18] Indeed, he

further argued that knowledge evolves through a process of social negotiation and evaluation of

the viability of individual understanding, where any conversation between two people presents

an opportunity for new knowledge to be obtained or present knowledge expanded.

Thinking about the computer as an educational tool in the context of social

constructivism, it becomes clear that computers can be used as tools to think *with*, rather than for

modeling the mind itself. Writing about hypertext and computers in 1988, Edward Barett

suggests that "language and the use of language for discovering and structuring knowledge

become the focus, with the computer supporting the social processes that define language use."[19]

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[18] Lev Semenovich Vygotsky, *Mind in Society: The Development of Higher Psychological Processes* (Harvard university press, 1980), 85.
[19] Edward Barrett, *Text, ConText, and HyperText: Writing with and for the Computer* (MIT Press, 1988), xxiii.

From this description, it is clear how hypertext-based tools can readily act as a digital environment through which learners can model and extend the social construction of knowledge.

By creating open, unstructured databases that allow for collaboration, learners can add and connect ideas, and support and challenge each other's perspectives. With the schema model for understanding knowledge acquisition and representation as interlinked connections between concepts, as well as the social constructivist notion of learning as a collaborative process of building shared representations of knowledge together, we might now turn to three examples of hypermedia learning tools which drew upon these network-oriented models of learning. These examples illustrate three different approaches to designing hypermedia knowledge organization tools that were used classrooms during this period, each which uniquely combined Bush's initial notions of hypertext and learning, the new computational capacities of the moment, and networked and collaborative models for understanding learning.

1.6 Intermedia

Intermedia was a hypermedia tool developed at Brown University from 1985 to 1991. While this project was a large and experimental undertaking, Brown already had a notably long history with hypertext projects. In the late 60's, Ted Nelson was at Brown developing "Hypertext Editing System" or HES, the first hypertext system able to run on commercial equipment that could be used by non-experts. Two years later, the HES project was replaced by FRESS (File Retrieval and Editing System) and was the first computer-based system to offer the "undo" feature. To a user today, interacting with the computer through FRESS would be completely unfamiliar; users would hold a light-pen over the document, and click a foot-pedal to create hyperlinks. FRESS is considered to be the first *educational* hypertext tool, and at Brown, it was

used primarily in humanities classes as an experimental way to present poetry as well as a word processor used by many students and professors.

Nearly twenty years later, the Institute for Research and Scholarship (IRIS) was founded at Brown in 1983 in an effort to develop a "scholar's workstation." One of those founders was Norman Meyrowitz, a researcher who had been involved with the earlier hypertext research projects. Norman led the project alongside Nicole Yankelovich, the lead software designer, a team of young software designers. The project was accompanied by a team of ethnographers who produced research papers about how the project was received as well as collected documentary footage.

At the outset of the project, the team described Intermedia as a vision to "create a vast multimedia information environment where no piece of information is ever isolated. Where every word, picture, and idea can be linked to any other."[20] Intermedia was not so much one tool as it was a suite of applications – which explains its plural name. Students referred to working with Intermedia as "going *to* Intermedia" because all the Intermedia terminals were housed in one room. To them, Intermedia was as much the software as it was the content held in the software, as it was the physical space that housed it. It was an entire experience.

IRIS launched their first Intermedia pilot with two classes at Brown, an English survey course and a biology course. The two courses were selected as a proof of concept of the flexibility of the system; if the same tool could be used to enhance learning in the distinct cultures of the sciences and the humanities, then surely it would be useful to a broader selection of courses. The professors for each course and the IRIS team built an entire corpus of reference materials for the work before the course began, inputting and linking hundreds of documents

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[20] CDS University Brown, *INTERMEDIA: From Linking to Learning*, 2011, https://vimeo.com/20660897.

together. Students could contribute their own content to their Intermedia environment by contributing their own writing, linking elements from their own or others' work together, or inputting other resource materials.

At the time, students clearly felt mixed about the authenticity of using Intermedia as a learning tool. To some, using Intermedia became an alternative, even a shortcut, to reading the course material. In the biology course, one student sheepishly admits that he did not once look at the textbook, but instead did all his preparation for the final exam using Intermedia. Several students in the biology class seem to describe using Intermedia as a kind of cheat – as if it already had all of the answers for them, or that it offered an easier way of reading than studying with the textbook. None of them explicitly described entering their own ideas into the system, or forging links of their own. This challenge regarding how much individual learners contribute to hypermedia systems, and whether they would add anything at all, is a core issue when dealing with participatory media more broadly, and one that would foreshadow difficulties across many of the other participatory hypermedia knowledge organization systems to come. In the documentary footage following students in the English course, one young woman says that having connections between material already made for them can be a blocker of originality. She describes a star student in her class, known for her originality, who she has noticed has begun making the same types of arguments and connections between material in her course as everyone else.
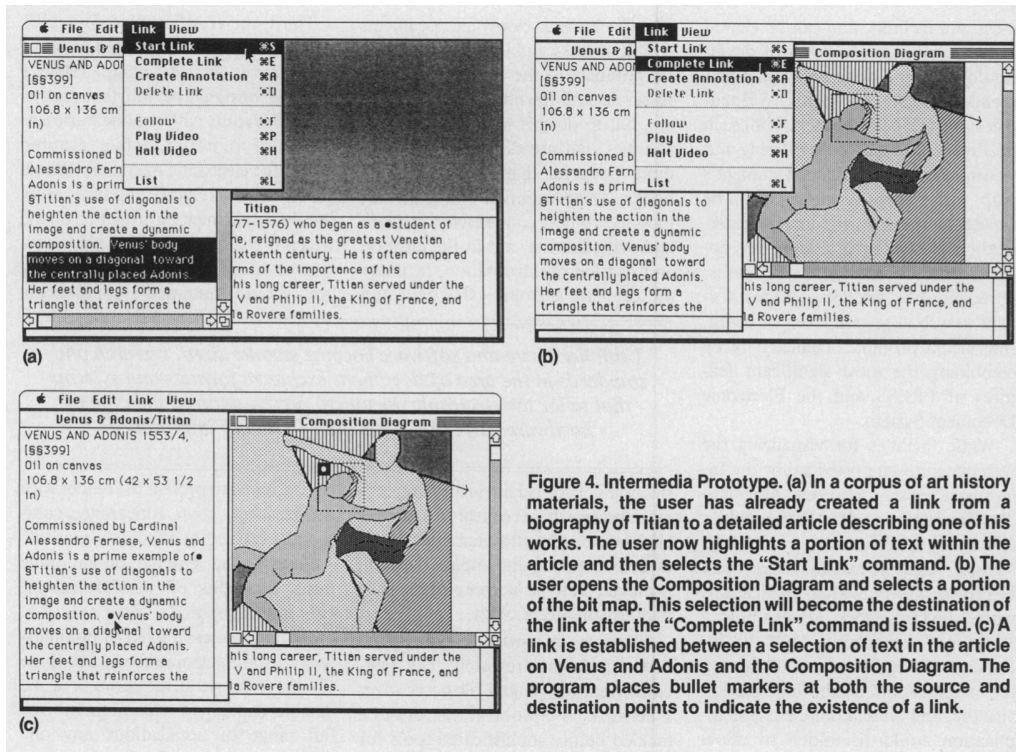
Figure 4. Intermedia Prototype. (a) In a corpus of art history materials, the user has already created a link from a biography of Titian to a detailed article describing one of his works. The user now highlights a portion of text within the article and then selects the "Start Link" command. (b) The user opens the Composition Diagram and selects a portion of the bit map. This selection will become the destination of the link after the "Complete Link" command is issued. (c) A link is established between a selection of text in the article on Venus and Adonis and the Composition Diagram. The program places bullet markers at both the source and destination points to indicate the existence of a link.

1985 Demonstration of Intermedia Showing How to Create Links and Anchors[21]

The two courses were evaluated quite differently as well. In the biology course, students prepared for a traditional pen-and-paper exam and were allowed to use Intermedia as a study tool. In the English course, students were given a week to make a concept map for all their ideas throughout the semester. With this final project, students were expected to think in a manner like how they had been working throughout the semester, reproducing the kinds of connections that they had explored through Intermedia. This final project had been done in a past semester, and the professor noted that this round had been a great success because students made far more connections than they had in years past: "The average concept map this year shows much more ability to relate ideas and many more ideas. But the important point about this is the way the

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[21]Yankelovich, Meyrowitz, and Van Dam, "Reading and Writing the Electronic Book," *Computer* 18, no. 10 (October 1985), 27.

student has been able to very quickly and economically show the relation of various themes and techniques to a very complex work. By relating all these ideas to the one subject of the concept map, she has given a quick Crash Course of English 32."[22]

The final version of intermedia included six applications: a word document writer, a timeline-maker, an animation editor, a video importer, and a mail system. Each of these applications was designed specifically to be able to support easy hypertext linking. Intermedia developed an "anchor" system to forge links between media. Any bit of text, image, or video content could attach an anchor to it, which then offered a small icon next to it which could be connected to other anchors – forging links. These anchors were quite novel because they would follow the content as it was edited. An anchor associated with a block of text would move with the text, even if new text was added before the anchor. Links in Intermedia were bi-directional, meaning that when a user clicks an anchor to follow a potential link, they are shown multiple options of where they can go next. Following a link to a new page wouldn't leave a user stranded at the new page; clicking the link on the new item can link the user back to the first. Furthermore, links could be multi-directional as well; one chunk of text could link to five different places, for example.

Having intermedia on shared servers meant that students' contributions could be used by anyone in the course. Using the animation tool, students could create visual representations and explanations of course content which could be linked into the system and used by anyone. Furthermore, communication through this network was entirely self-contained. Students could send the equivalent of emails to professors or peers which could link directly to course content. The same type of link could take you to a previous email in the chain.

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[22] CDS University Brown, *INTERMEDIA: From Linking to Learning*, 2011, https://vimeo.com/20660897, 22:49.

One particularly interesting aspect of the Intermedia environment was how it used an early formulation of a "web" metaphor. In hypermedia the "web" was a side-panel view which allowed learners to visualize their path between linked documents.[23] Turning on the web view initialized all the anchors and links in the database; the connections between documents were stored in this separate layer that could be applied on top of the media forms rather than altering the documents themselves.

1.7 Computer Supported Intentional Learning Environments (CSILE) and Knowledge Building

A second program for using hypermedia for collaborative learning developed from the partnership of Scardamalia and Bereiter, a Canadian learning research duo who have been working together since the 1970s. Their work focused as much on changing fundamental classroom cultures and dynamics as on building digital learning environments, largely around their research in "knowledge building." In many ways work is emblematic of an approach to rethinking schooling and learning by drawing on both the affordances and excitement around new technologies to experiment with new pedagogical practices in schools. This type of approach is most obvious in Seymour Papert's 1984 description of the computer "blowing up" the school, where he described that the notion of school as defined by "something where there are classes, teachers running exams, people structured in groups by age, following a curriculum" is fundamentally incompatible with the presence of computers in the classroom.[24]

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[23] CDS University Brown, *INTERMEDIA - A Retrospective*, 2011, https://vimeo.com/22749137.
[24] Larry Cuban, *Teachers and Machines: The Classroom Use of Technology Since 1920* (Teachers College Press, 1986), 72.

To frame Scardamalia and Bereiter's approach towards knowledge building with hypermedia knowledge organization tools in the classroom, their prior research had centered around developing what they called *intentional learning* and cognition. Intentional learning practices are "something more than 'self-regulated learning,' more like the active pursuit of a mental life."[25] Students are given high levels of agency for meeting learning objectives and managing knowledge and competencies. In articulating intentional learning, Scardamalia and Bereiter explicitly challenge existing classroom structures and communication patterns, suggesting that many common classroom practices serve as obstacles to intentional cognition.

One of the primary problems that they identify is the flow of information being primarily from the teacher to students rather than feedback between the students. This "dysfunctionality" is apparent in typical classroom assignments, where students developing projects (in younger years) or research and course papers in higher education, only share their work with educators who can provide brief and one-sided feedback, aside from the occasional bulletin-board public display of work. Rather, for learning communities themselves to become a sustaining force for "knowledge advancement" they argue that knowledge-related goals must be more than goals that are satisfying for the teacher, and that those goals could be reached through student-to-student feedback.

Much of this early work was described in "Schooling and the Growth of Intentional Cognition: Helping Children Take Charge of Their Own Minds," which was published in 1983. In this five-year research project, they developed a learning environment called CSILE, or Computer Supported Intentional Learning Environment. While the early versions of CSILE were entirely text-based and developed for graduate level students, the first extended research using

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[25] Marlene Scardamalia and Carl Bereiter, "Higher Levels of Agency for Children in Knowledge Building: A Challenge for the Design of New Knowledge Media," *The Journal of the Learning Sciences* 1, no. 1 (1991): 37.

CSILE was with sixty-four fifth-grade students. CSILE ran on ICON microcomputers, a type of networked personal computer that had been developed in the 1980s and funded by the Ontario Ministry of Education.

Scardamalia and Bereiter appear to not have published any technical documentation, demos, or screenshots of how users interacted with early versions of CSILE, and clear articulations of these earliest experiments with networked are quite limited. However, in their 1989 publication titled "Computer-Supported Intentional Learning Environments," they describe some of the general functions of the software. Scardamalia and Bereiter articulate four characteristics of passive or immature learners that they hope to help subvert with the design of CSILE. These include: "1) the organization of mental activity around topics rather than goals, 2) a focus on surface features, 3) the use of straight ahead rather than recursive procedures, and 4) an additive rather than transformational approach to learning."[26] They describe a general design methodology "procedural facilitation" as the means by which CSILE systems will provide support, which involves presenting knowledge-structuring environments, formats, retrieving information, and helping learners to make choices and monitor sequences of events. Furthermore, CSILE also promised to offer multiple ways of representing knowledge that are simultaneously accessible through the shared database. Students could create maps and other diagrams and were able to attach their own notes and arguments onto these representations. In CSILE, students develop the knowledge base, responsible for entering their own knowledge and ideas into the system, and "evaluating it, interrelating it, labelling it, and sorting it, and

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[26] Marlene Scardamalia et al., "Computer-Supported Intentional Learning Environments," *Journal of Educational Computing Research* 5, no. 1 (February 1, 1989), 53.

performing periodic reorganizations and house cleanings to enhance the quality of the

community knowledge base."[27]
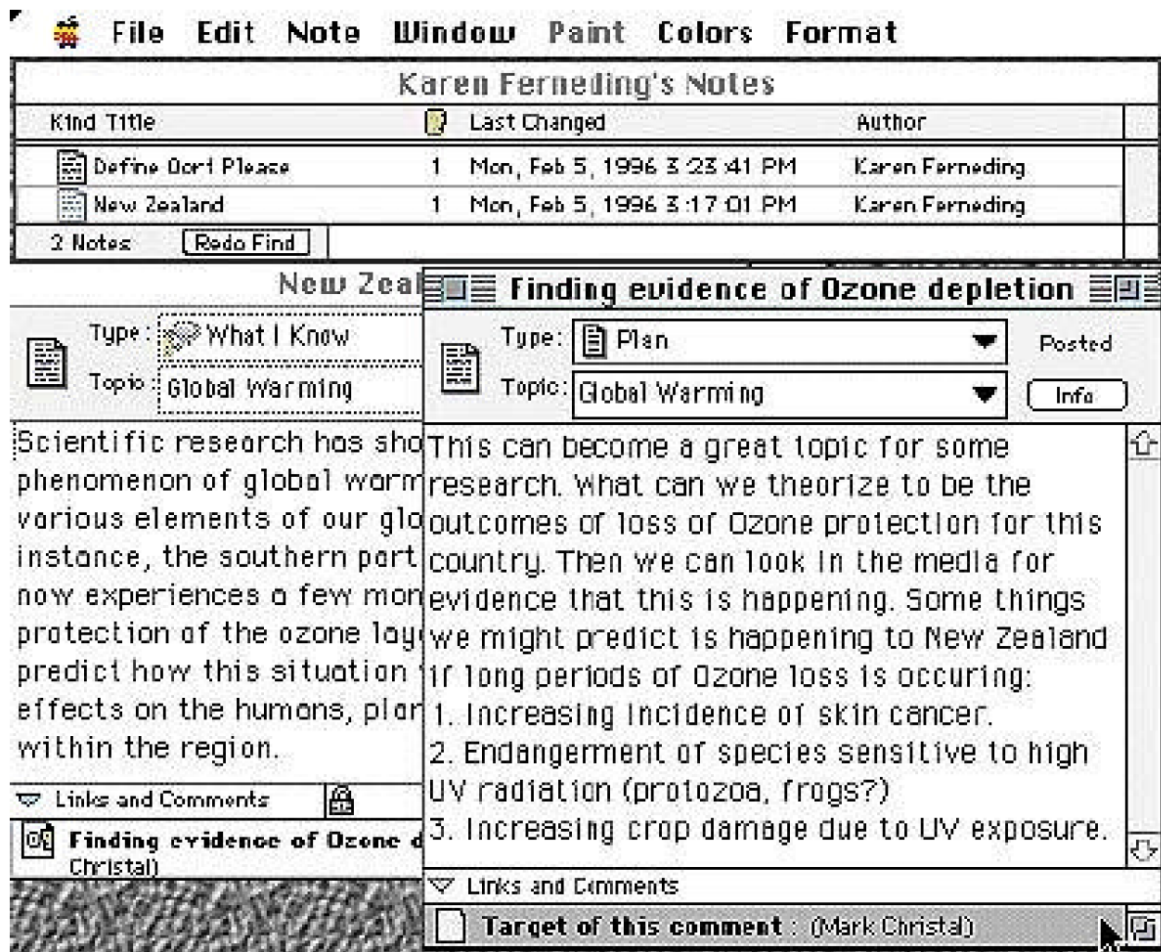
Linked Notes in MacCSILE [28]

By the late 1980s, the CSILE software project grew into a partnership with Apple, and

the software was fully redesigned for new Macintosh computers and rebranded as MacCSILE.

Starting from essentially a blank database, students write either textual or graphical notes to

describe their theories and ideas. These notes live in a shared classroom database, where other

students can collaboratively find evidence to add context, commentary, or counterexamples to

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[27]Scardamalia et al., "Computer-Supported Intentional Learning Environments," 63.
[28] Mark Christal, Karen Ferneding, and Adrienne Puthoff, "Schools as Knowledge-Building Communities," December 8, 1997, 17.

their peers' theories. The CSILE system provides note prompts which encourage the formulation of theories and sustained inquiry, like "Problem," "Question," "New Learning," or "What I know." Each note that is added to the database is tagged with the author's username, and all notes added to the database are public.

MacCSILE allowed students to search across authors, topics, or thinking prompts. Scardamalia and Bereiter intentionally allowed for cross-subject searchers to move away from the siloing of content knowledge into school subject areas, which they argue contributes to students' struggles to transfer knowledge between subject areas.[29] Furthermore, MacCSILE allows students to create links between comments and other bits of content, such that learners can add layers of commentary onto their peers' conjectures which can automatically link back to the original idea. Students could also create hyperlinked labels between their notes and graphical content.

1.8 HyperCard

Many consider HyperCard to be a particularly significant point in the development and popularization of hypermedia tools. Created by Bill Atkinson at Apple and announced in 1987, HyperCard was marketed as a user-friendly and flexible hyperlink-based programming environment that could allow non-programmers to create interactive experiences. While HyperCard was lauded as an educational technology which offered educators and learners opportunities to create networked tools, activities, and games for the classroom, HyperCard stands apart from the other two cases discussed in this chapter because it was not designed

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[29] Scardamalia et al., "Computer-Supported Intentional Learning Environments," 64.

explicitly as an educational tool. Many of the early interactive experiences designed in HyperCard might look reminiscent of basic clickable websites. HyperCard's interface is designed around physical card metaphors, where users can view the top "card" of a self-contained "stack," or collection of cards that have their own set of media and interactions.

Any card in HyperCard has two layers, a *background layer,* and a *card layer*. The background layer is a reusable layer, like a template, which holds buttons, graphics, and fields that can appear across multiple cards that use the same background across the entire card stack. And correspondingly, a *card layer* holds all the same object types but are arranged uniquely on each individual card. Using both the template background layer and the card layer allowed users to create stacks of cards which had repeated interactions (like "next card" and "previous card" buttons that were always in the same location) while also allowing users to quickly customize each card as well.

HyperCard users designed interactions with the buttons and text fields using a development language called HyperTalk. HyperTalk was an intentionally easy programming language to learn, with syntax and grammar that closely resembled English. Each object on a card could have its own small program attached to it such that individual objects on a card could be designed to allow the user to jump to other cards in the stack, manipulate information stored in a text field, and other types of interactions. Users could place invisible buttons on top of images to create the illusion that clicking on the image would have an effect.

By writing user-friendly scripting for these buttons, users create cards which could play animations, make sounds, create spreadsheets, and perform tasks. In HyperCard, exploring a stack of cards was called "browsing," a term that was usurped by internet interactions, like many of the interactions proposed by HyperCard. HyperCard was also easily modifiable and

extendable, such that users could readily install and tinker with others' scripts to create their own HyperCard stacks.

HyperCard gained immediate notoriety upon its release for several reasons. First, HyperCard was freely available on all Macintosh computers, which significantly lowered the barrier of entry to begin experimenting. Furthermore, the HyperTalk scripting language and general programming environment was intentionally designed to be intuitive enough that inexperienced computer users and non-coders were able to quickly learn how to build HyperCard stacks, which allowed for a wide variety of types of experiences to be developed. Many people who otherwise would not have coded at all began experimenting with basic coding for the first time using HyperCard. An article in 1988 InfoWorld magazine describes the beauty of HyperCard being that "it lets people program without having to learn how to write code."[30] Both its accessibility and usability made HyperCard incredibly open to educators that were interested in experimenting with pre-made interactive tools who already had Macintosh computers in their classrooms, as well as educators who were interested in quickly creating their own interactive learning tools.

HyperCard was also subject to its fair share of hype and excitement, in part because it was widely adopted and used at a point when hypertext was quickly becoming more of a buzzword. Indeed, some technologists even saw the interactive nature of HyperCard as addictive, saying things like "the reason I think that most of the significant new Mac software will be HyperCard based is because Mac users won't be able to tear themselves away from it long

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[30] Inc, InfoWorld Media Group. *InfoWorld*. InfoWorld Media Group, Inc., 1988.

enough to create anything else."[31] As HyperCard decks began to be used in schools, these fears were translated to children as well, with tech articles quoting educators and parents saying: "..and do we really want to give hypertext to young school children, who already have plenty of distractions? After all, if a child is studying a lesson in ancient history, we really don't want him to click on the section where the Chinese invent gunpowder and end up in a chemistry lesson on how to create fireworks in the basement."[32]
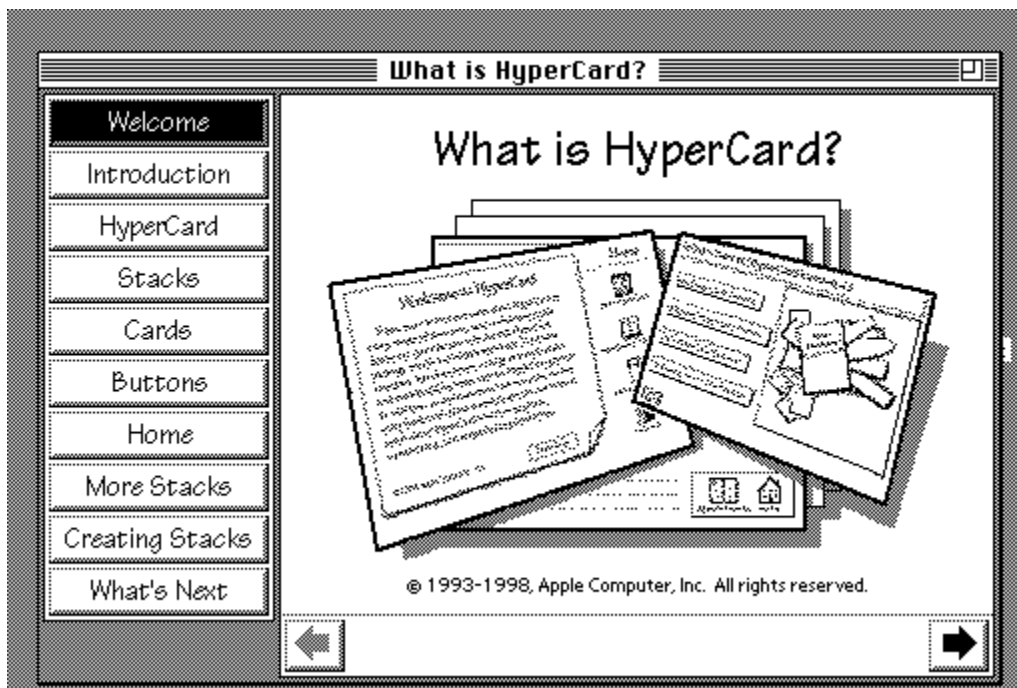
Opening Screen for HyperCard 2.0 [33]

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[31]Leemon, Sheldon. "Microscope: The Hazards of HyperCard," April 1988. https://www.atarimagazines.com/compute/issue95/049_1_MICROSCOPE_THE_HAZARDS_OF_HYPERCARD.php.

[32]Leemon, "Microscope: The Hazards of HyperCard."

[33] "What Is HyperCard? V2.3 : Apple Computer, Inc. : Free Download, Borrow, and Streaming : Internet Archive." Accessed March 16, 2021. https://archive.org/details/hypercard_what_is_hypercard_2.

HyperCard was used in classrooms in a wide variety of different ways throughout its development. Educators could purchase commercial learning experiences that were built using HyperCard, that were less oriented towards having students create their own hypermedia designs and were more a packaged interactable experience. Some educators used HyperCard to replicate existing educational tools, create presentations, multiple choice question card stacks, and basic calculator tools. Others used HyperCard for developing educational games. For example, "Flowers of Crystal" was a puzzle-solving and adventure game that taught critical reasoning skills for elementary school students.

Some educators used HyperCard to design non-linear experiences that learners could follow but would not modify or add to on their own. For example, over the course of a semester Hilary McLellan exposed fifth-grade students to a series of HyperCard-based nonlinear narratives, alongside lessons which taught about the various components of narrative structure and traditional storytelling. The HyperCard narratives offered a variety of clickable images, animations, and sound effects. At the end of the semester, after having been trained in the basics of creating HyperCard stacks, the students developed their own non-linear stories and illustrations which they then transferred into HyperCard and shared with their peers.[34]

One other substantial series of experiments with HyperCard in classrooms was organized by Apple, as an experiment to investigate if computers change the way teachers teach, and whether they simplify or complicate teaching. Beginning in 1985, Apple's program, called "Apple Classrooms of Tomorrow," brought Apple computers into seven K-12 classrooms across the United States and gave participant teachers and students computers for the classroom and computers to bring home. Their reflections on bringing HyperCard into classrooms described

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[34] McLellan, Hilary. *Narrative and Episodic Story Structure in Interactive Stories*, 1992. https://eric.ed.gov/?id=ED348012.

students using HyperCard for a variety of self-directed goals and projects, like creating animated

stacks for demonstrating problem-solving techniques, and building lessons for their peers.[35]

HyperCard was a tool which could offer hypermedia-based knowledge organization

practices using its scripting language and hypermedia format. However, unlike CSILE and

Intermedia, HyperCard appeared to take on a far wider range of use-cases in the classroom

beyond the types of social constructivist and knowledge organization-oriented practices that the

other two tools tended towards in classroom environments. This can be attributed both to the fact

that HyperCard had a far wider adoption than the other previously mentioned tools, and that it

was not designed with specific learning-oriented scaffolds.

1.9 Conclusion: Plural Visions of Hypermedia Classroom Learning

The development and classroom applications of each of the three case studies discussed

in this chapter were shaped by the emerging technological conditions of the moment, built upon

the notions of hypertext and learning set forth by Bush, and engaged with new pedagogical

practices in the classroom. Looking across these platforms at their similarities and differences,

we can first return to the three conjectures based on the reading of Bush's "As We May Think"

that began this chapter, to examine how they each make use of hypertext in the learning context.

As hypertext tools, each engages with the notion that ideas are fundamentally connected,

and that creating and mapping these connections is a meaningful educational act. The basic

interaction of creating a new node with one's own ideas, whether through a card, note, or an

anchor metaphor, is central to each of these systems and is used as an act of creating or sharing

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[35]David Dwyer, "Apple Classrooms of Tomorrow: What We've Learned - Educational Leadership," ACSD.org, 1994, http://www.ascd.org/publications/educational-leadership/apr94/vol51/num07/Apple-Classrooms-of-Tomorrow@-What-We've-Learned.aspx.

knowledge. Intermedia and HyperCard was designed to support a plurality of media as nodes, while CSILE prioritized offering scaffolds to help students enter text-based nodes.

All these systems offered opportunities to create "trails" through these bodies of knowledge. In CSILE and Intermedia, learners could draw links between documents, even when they were not authored by the user. In Intermedia, this path metaphor was made explicit with its "web" window, which offered learners a visualization of their own history through the database as they explored between documents.

Finally, the collaborative aspect of both tools is central to their pedagogical function. Bush predicted that an expert in a subject area might share their associative trails with a novice to assist them in quickly understanding a subject area. Both Intermedia and CSILE extend this approach with a social constructivist perspective; rather than creating chains of connection and passing them from one learner to the next, learners simultaneously contribute their knowledge to build one single interconnected database that is representative of their learning community's knowledge. Thus, both systems become emergent structures, such that nodes exist and are discoverable through their relationships to other nodes, rather than in a hierarchical system.

To contrast the three cases, the practical intentions and imagined scope of Intermedia and CSILE, and HyperCard are all quite different. Intermedia was imagined as a suite of tools that would be used outside of the classroom; students would *go to* hypermedia which could enable new collaborations, research, study, and practice methods, and insight. The effectiveness of Intermedia was described and studied by how they improved existing classroom discussions (in the English course) or performance on exams (in the Biology course). Scardamalia and Bereiter's vision for how this kind of hypermedia learning tool would be situated in the classroom is quite different. They imagined CSILE and as a model through which the classroom dynamic could

dramatically shift and developed the tool with explicit pedagogical practices in mind. Like CSILE, HyperCard was also purported to have dramatic effects on classroom learning, however it was designed as a much more open-ended platform that could be used in a variety of non-classroom contexts as well; its mere presence as a platform to enable open-ended networked creative work was described by its advocates to inherently offer new opportunities for creative and collaborative work in classrooms.[36]

Each of these new environments for thinking and learning reinforce the propositions that Bush put forward in his initial ideas about using associative practices as a way of connecting and creating knowledge. Building on these notions and the simultaneous technological advancements of the day, they both set forth new digital environments and dynamics for learning that occur both in and out of the classroom. Returning to these systems from the perspective of a learner today, they still seem immensely novel and boundary-pushing. It is quite remarkable that these tools were not only able to run on these early networked computers, but they were able to have positive impacts on the classrooms that they were in. These tools were not merely provocations for collaborative learning experiences as was Bush's Memex – these learning technologies actually saw the light of classrooms, and seemed, at least at the time, to have made the case for their effectiveness. Looking from the vantage point of 35 years later, it might seem curious that despite all the promise of these technologies, they seem not to have dramatically shifted the landscape of education to the degree that they had hoped. Shifting now from the dreams of the hypermedia-enabled classroom, we can turn to the changing conditions in the ensuing decades which absorbed the ambitions of many of these tools.

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[36] Knapp, Linda. "ACOT Classroom Networks: Today and Tomorrow. ACOT Report# 5.," 1989.

Wikis and Classrooms

2.1 Introduction

The early age of networked computing ushered in a renewed optimism about the variety of potential applications of hypermedia in the development of digital learning tools. Even as the tools discussed in the previous chapter were discontinued (Intermedia), changed form (CSILE became Knowledge Forum), or continued to grow in popularity (HyperCard), the ubiquity of networked computing ushered in continued excitement about hypermedia-based learning tools through the mid-1990s. This chapter will follow a focus shift away from hyper-specialized and feature-heavy hypermedia knowledge organization tools like CSILE and Intermedia and towards a new kind of internet-enabled platform for collaboration called the *wiki*. Directly inspired by earlier hypermedia applications, wikis are a type of collaboratively editable hypertext publication that is accessible using the web browser. The move from tools like Intermedia and CSILE to the wiki in educational contexts marks a broader shift away from hyper-specialized and dynamic hypermedia and toward a less flexible but more accessible wiki model. Even despite this shift towards tools that seem more conservative from the perspective of its range of hypertext features, much of the earlier excitement about hypermedia tools carried over into wikis as a model for hypermedia learning, which many believed still had the potential to fundamentally change classrooms.

Like the tools discussed in the previous chapter, the wiki ultimately did not gain substantial traction as a widespread educational technology for the classroom. In this chapter, I

argue that the failure of the wiki's adoption is due to a combination of fundamental aspects of the wiki's design which created challenges in collaborative classroom environments, as well as a common set of uses for wikis which were misaligned with typical classroom contexts. Together, these design features and pedagogical misalignments led to the failure of wikis as broadly applicable tools for use in schools.

There are four key lessons to draw from wikis when considering the applicability of hypermedia knowledge organization tools in classrooms more broadly. These lessons will play out across the chapter both through an examination of the wiki's history and design, and in relation to research studies describing how wikis were used in classrooms. In terms of design, wikis simplified many earlier hypermedia platform features for the sake of usability, which discouraged creating varied types of associations between information, and deprioritized the visualization of connections between nodes. The first lesson is that many of these simplifications were detrimental to accomplishing learning goals. A second lesson from the wiki design is that synchronous editability and integrated spaces for annotation and discussion are crucial when students engage with activities that are intended to be collaborative.

When considering how wikis were used in classrooms, there are two additional important lessons that will unfold throughout this chapter. First is that traditional models of assessment and non-traditional models of collaboration and knowledge-building are typically incongruous. Hypermedia tools can only be effectively brought into classrooms that expect traditional modes of assessment when using activity designs which create clear boundaries between individual and shared contributions or should be used in contexts where students do not need to be graded as individuals. Relatedly, collaborative activities in these types of environments tend to best unfold

across activity series with extended durations, where students are developing connections between ideas over extended periods of time across multiple small-scale projects or assignments.

2.2 Late 1990s-Early 2000s

Before discussing the specific reasons for failure, this chapter will first examine how the emergence and excitement around "Web 2.0" technologies and platforms set the stage for wikis to become a site for educational experimentation which built upon aspects of earlier hypermedia tools used in education. The 1990s did not see the continued rapid development of new hypermedia learning tools from the decade before, but instead was marked by deeper consideration and study of the tools and techniques used in the late 1980s. Indeed, after years of experimentation with hypertext tools in classrooms, many hypertext researchers had misgivings about their efficacy in classrooms. Some educators argued that the exploratory nature of hypermedia was inherently incongruous with the classroom context, as was the constructivist model more broadly. Writing in 1992, Gabriel Jacobs describes the frustration with constantly being informed that educators are "on the brink of an educational revolution" of non-linear exploratory learning. Looking through the history of Western education, he pointed to a variety of examples from the ancient Greeks to Jean-Jacques Rousseau, to indicate that the pendulum has constantly swung between "rote" education and exploratory learner-centered (or "discovery-based") education, and that learner-centered education has nearly always failed.[37]

Others suggested that this failure was because there was an overemphasis on the tools, and a lack of planning for how hypermedia platforms would function in classrooms, even if the

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[37] Gabriel Jacobs, "Hypermedia and Discovery-Based Learning: A Historical Perspective," *British Journal of Educational Technology* 23, no. 2 (May 1992): 113–21, https://doi.org/10.1111/j.1467-8535.1992.tb00317.x.

tools themselves worked well. Nunes & Fowell (1996) suggested that the previous educational

hypermedia tools failed because the applications did not have appropriate theoretical models to

explicitly define an educational approach for how they would be used. They suggest that

hypermedia platforms need guidance and navigational systems that can be tailored by the

educator and readily understood by the learners for specific educational contexts, rather than

general purpose tools.[38] Johnson & Johnson, writing in 1996, cited the failure of schools to adopt

instructional technologies as due to the fact that the technologies themselves were not yet

explicitly focused on collaboration and cooperative learning.[39] This idea also ties into the

challenge that many of the early computers themselves were not accessible and affordable

enough for wide adoption in classrooms. Despite seemingly glowing reviews of their usage in

many research studies, the tools for accomplishing collaborative hypermedia were too

cumbersome; creating the networked platforms like Intermedia was still very slow and required

specialists. There simply wasn't enough institutional support to continue funding some of these

tools, and the tools themselves were not yet ready.[40]

One of the broad challenges with educational hypermedia experiences that was described

throughout this period was learners getting "lost" in hypermedia experiences, or that the systems

did not have enough guidance to support learners. In a survey of hypertext in 1987, Conklin

described this phenomenon as the "disorientation problem," where information that is spread

across hundreds or thousands of nodes can easily be forgotten or difficult to relocate.[41] When

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[38]Susan P. Fowell Jose Miguel Baptista Nunes, "Hypermedia as an Experiential Learning Tool: A Theoretical Model" (Professor T.D. Wilson), accessed March 17, 2021, http://informationr.net/ir/2-1/paper12.html.
[39]David W. Johnson and Roger T. Johnson, "Cooperation and the Use of Technology," accessed March 17, 2021, http://members.aect.org/edtech/ed1/35/index.html.
[40]"Brown CS: A Half-Century Of Hypertext," accessed March 10, 2021, https://cs.brown.edu/events/halfcenturyofhypertext/.
[41] Jeff Conklin, "Hypertext: An Introduction and Survey," *Computer* 20 (October 1, 1987): 17–41, https://doi.org/10.1109/MC.1987.1663693, 37

faced with unfamiliar information environments that have already been pre-filled with large amounts of information, learners can have difficulties when attempting to "gain an overview of the subject material, and they have trouble finding specific information even if it is present;" they even may miss large and important sections. José Miguel Baptista Nunes and Susan P. Fowell describe three types of complexities when engaging with these types of environments: managing oneself in the complex learning environment, encountering conflicts with one's previous understandings and models of the world, and simultaneously trying to understand a new content domain while following a new approach to learning. When the hypertext system is confusing and becomes its own source of complexity, this can quickly lead to experiences of "information overload," which makes it much more challenging to learn from the encounter with the hypertext system.[42]

When first encountering a new subject presented in the format of a vast hypertext or hypermedia network, students often face an overwhelming series of choices and do not know where to start, particularly in contexts where they are not provided with a map or index. In contexts where learners are not adding in their own content from scratch, they may not naturally intuit the logic behind the associations between information. Some learners have noted difficulty re-finding information when they do not understand the intended meaning of the creator's associations. Furthermore, some researchers found that following paths of association in hypertext environments is not alone enough to account for deep and engaged interaction with the content itself. When reflecting on Intermedia, Nicole Yankelovich, one of the heads of the development, suggested that some students showed no learning benefits, possibly because they

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[42]José Miguel Baptista Nunes and Susan P. Fowell, "Hypermedia as an Experiential Learning Tool: A Theoretical Model" (Professor T.D. Wilson), accessed March 17, 2021, http://informationr.net/ir/2-1/paper12.html.

were "passively" using the system rather than "actively" using it.[43] In considering these challenges Hammond (1992) suggests explicitly developing activities using hypertext that promote active engagement by "forcing the learner to think about the structure of the material as it is presented or by providing specific activities which demand structure to be abstracted," like quizzes, demonstrations, and problem-solving activities.[44]

Despite the failure of the tools from the 1980s and early 1990s to gain widespread traction in classrooms, by the mid-1990s it was becoming increasingly clear that the world was rapidly changing alongside the development and mass popularization of computers and the early Internet. In popular educational discourse, there was a plurality of descriptions of what this future computer-enabled world would look like, and notions of how to adapt educational practices to prepare learners for this new landscape. One popular theorization of this rapidly-approaching digital world was Manuel Castells' 1996 book *The Network Society,* which argued that the current moment was facing a transformation in our material culture by a "new technological paradigm organized around information technologies."[45] As such, the revolution is not only characterized by the production of knowledge, but "the application of such knowledge and information to knowledge generation and information processing/communication devices in a cumulative feedback loop between innovation and uses of innovation."[46] These types of admittedly technologically determinist visions of a networked and information-oriented future were compelling and reached education communities, particularly ones already focused on

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[43] Yankelovich, Meyrowitz, and Van Dam, "Reading and Writing the Electronic Book," *Computer* 18, no. 10 (October 1985): 15–30, https://doi.org/10.1109/MC.1985.1662710.

[44] Nick Hammond, "Tailoring Hypertext for the Learner," in *Cognitive Tools for Learning*, ed. Piet A. M. Kommers et al., NATO ASI Series (Berlin, Heidelberg: Springer, 1992), 149–60, https://doi.org/10.1007/978-3-642-77222-1_11, 156.

[45] Manuel Castells, *The Rise of the Network Society*, 2nd ed., with a new pref, The Information Age : Economy, Society, and Culture, v. 1 (Chichester, West Sussex ; Malden, MA: Wiley-Blackwell, 2010), 29.

[46] Castells, *The Rise of the Network Society*, 32.

networked educational technologies. In response to these sentiments, many educators believed that in a networked 21st century, learners would need skills to be able to work collaboratively and creatively with others and be able to critically examine the influx of information that they were able to access.

While some of the excitement that was specifically focused on creating new collaborative hypermedia environments and tools had faded out of frame, the push to find new ways of using computers to support cooperation and collaboration in classrooms was continuing to gain momentum throughout the 1990s. This was in part intensified by the growing notion that new literacies in technology and in cooperation and teamwork would become increasingly vital skills in the 21st century, just as emerging media technologies were expected to become increasingly ubiquitous.[47]

One growing branch of researchers focused on collaboration in the classrooms formed a community around developing "Computer-Supported Collaborative Learning," (CSCL) which began hosting biannual conferences in 1995. Marlene Scardamalia and Carl Bereiter were early contributors to this growing body of research, and their work on CSILE matured into commercial learning software called Knowledge Forum. Their work on theorizing knowledge-building communities and discourse, as well as intentional learning are concepts that have become foundational to CSCL. Computer-Supported Collaborative Learning is a pedagogical approach that prioritizes social, peer-driven learning that is mediated by computer-based interactions. CSCL pedagogies involve shared knowledge construction through the use of technology. This mode of learning can take place in the classroom in conjunction with face-to-face interactions or using computer-based technologies as the primary mode of communication for students at a

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[47] David W. Johnson and Roger T. Johnson, "Cooperation and the Use of Technology," 1996, http://members.aect.org/edtech/ed1/35/index.html.

distance. It also includes both synchronous and asynchronous modes of shared learning and knowledge construction. Gerry Stahl, one of the well-known theorists within the discipline, has described CSCL along four axes: collaborative knowledge building, group and personal perspectives, mediation by artifacts, and micro-analysis of conversation, or "interaction analysis."[48]

As a field, CSCL takes the stance that the use of shared computer-based interactions can support groups of learners to collectively construct ideas, questions, and understandings. This work draws on Vygotsky's research on the social basis of knowledge, recognizing that meaning and learning "[emerge] from interpersonal interactions."[49] Furthermore, knowledge-building is fundamentally mediated by "artifacts," or resources with which learners can share and imprint meaning. CSCL proposes that computer-supported technologies offer an opportunity to foster new modes of collaborative learning and knowing, breaking away from the teacher taking the primary role of transmitting knowledge which students passively receive. As the wiki later began to be considered as a hypermedia tool that could be used within educational practices, the growing CSCL community already had a set of pedagogies and a design vocabulary that could readily be applied to creating wiki-based learning experiences. Much of the research that would go on to experiment with uses of wikis in the classroom in the ensuing years brought notions about networked collaboration and interpersonal interaction from CSCL into its applications and continued to expand them.

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[48] Gerry Stahl, "Contributions to a Theoretical Framework for CSCL," in *Proceedings of the Conference on Computer Support for Collaborative Learning Foundations for a CSCL Community - CSCL '02* (the Conference, Boulder, Colorado: Association for Computational Linguistics, 2002), 62, https://doi.org/10.3115/1658616.1658626.
[49] Stahl, "Contributions to a Theoretical Framework for CSCL," 6.

Through the first few years of the internet into the late 1990s, technological advances in networked computing offered new hopes for accessible, wide-scale networked collaboration and shared digital community spaces. A typical user's experience of the internet throughout this time, if they had any at all, primarily involved publishing and engaging with content on static webpages. However, the wiki format was emblematic of a new model which promised to facilitate new types of collaborative behavior on the internet by making websites that were openly editable within the browser itself.

While the general format of the wiki is likely familiar, most obviously with the example of Wikipedia, I will first describe some of the history and aspirations of the initial creator of the wiki, before moving to how the tool was imagined in different kinds of classrooms. Though the wiki format grew in popularity with the Web 2.0 tools that became the norm in 2005, Ward Cunningham published the first wiki a decade earlier, on March 25, 1995. Cunningham began experimenting with the Wiki model in the late 1980s after an experience playing with HyperCard, which completely blew him away. On his personal blog, Cunningham describes developing initial ideas for a Wiki using a HyperCard stack in the late 1980s, where he created a stack of cards using three basic types: cards for ideas, cards for people who hold ideas, and projects where people can share ideas.[50]

Cunningham's first Wiki was called "WikiWikiWeb" which was designed as a companion to the Portland Pattern Repository, a repository for computer programming software design. patterns. He named the tool "WikiWikiWeb" after the Hawaiian "Wiki Wiki," which means "very quick" – and Cunningham's initial idea was focused on increasing the speed of

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[50] Ward Cunningham, "Wiki Wiki Hyper Card," accessed March 6, 2021, https://kidneybone.com/c2/wiki/WikiWikiHyperCard.

building collaborative networks. He believed that making a collaboratively editable platform would help developers to more rapidly be able to share software design patterns.

At the time when the internet was still in its "1.0" phase, the groundbreaking aspect of this initial project was that the wiki could be edited by users directly on the website – users could both write and read in the same place. This was unique at a point in the development of the early internet where users typically needed separate authoring tools to create work that they could then later publish online. This type of user activity of "writing where you read" was in part a realization of the early dreams of the internet as hosting being spaces that were interactive and collaborative.

By 2005, the broad shift toward a more highly participatory Internet only further fueled the excitement about participatory web-based learning tools. This shift in how websites were designed was described as "Web 2.0" a term that was popularized in 2004 to describe new websites that were structured to enable user-generated and participatory content and interactions. This marked a turn away from static web pages (which were retroactively dubbed as "Web 1.0") to digital formats like blogs, social networking, and wikis. Embedded within this model of collaboration and interactivity is the notion of the hyperlink and the network. In 2005, Tim O'Reilly, whose company hosted the original Web 2.0 conference, wrote a seminal brief on the design patterns and business models for Web 2.0. In the piece O'Reilly describes hyperlinking as a fundamental aspect of the internet, that "as users add new content, and new sites, it is bound into the structure of the web by other users discovering the content and linking to it. Much as synapses form in the brain, with associations becoming stronger through repetition or intensity,

the web of connections grows organically as an output of the collective activity of all web users."[51]

Many educational researchers took this collaborative potential and growing popularity of the Internet and imagined how these tools could be used in concert with constructivist learning strategies to enable learners to more effectively participate in a networked society. Of these new Web 2.0 forms that were rapidly growing in popularity, the wiki became a primary format onto which researchers began to imagine new possibilities of developing constructivist possibilities for developing collaborative learning experiences in the classroom.

2.3 Structure and Design of the Wiki

As a type of platform which ran on the early internet, wikis have several characteristics that overlap with early inspirations of hypertext. Wikis simplify the process of creating hypertext-based writing by offering a simplified syntax for content markup that runs within the browser. Wikis themselves are composed of dynamically generated HTML pages, which are linked to form a network that can grow dynamically as new pages are added to them, much like the types of hypermedia tools discussed previously.

While the simplicity and clarity of the wiki form was important in enabling its widespread adoption, there are clear limitations to the generic structure of wikis when comparing them to the hypermedia tools examined in the previous chapter. Many of the hypermedia forms that examined in the previous chapter take the "node" in a network to be a small chunk of information, which could simultaneously connect to many other pieces of information at once. In

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[51] "What Is Web 2.0," accessed March 5, 2021, https://www.oreilly.com/pub/a/web2/archive/what-is-web-20.html.

Intermedia, an image could be attached to a page about one topic and a page about another completely separate topic, and clicking on the image itself would indicate the other contexts in which that image lives. In comparison, the base "node" of the Wiki is a full page, often composed of many paragraphs of writing and multiple images. Any link on a traditional Wiki will take the reader to another page, rather than to a specific piece of media, like a paragraph or a single image.

Like the rest of the internet, wikis use unidirectional links rather than the bi-directional links that the early hypertext pioneers advocated for. When linking from one page to another within a Wiki database, making links are one-way pointers from one page to another. However, when you are on a page, the page itself does not typically generate information about the other pages which point to it. Some Wikis do offer separate backlink finders, where a user can type in a single page reference and see all the other pages which point to it. Wikipedia has a page called "What links here," that serves this purpose.[52] However, obscuring these backlinks from the pages themselves in Wikis deprioritized the notion that single pages are situated in multiple other contexts, and that recognizing and following those multiple contexts is a useful interaction.

While the pages of wikis are structured non-linearly and non-hierarchically, wiki pages themselves are typically read linearly like the page of a book, with the main text taking up much of the page, and supplemental images and graphics set to the right or left of the main content. Users can only view one page on a wiki at a time within a single browser window. This model significantly limits the types of activities and extent of interconnection that users can create on its pages. And yet this simplicity can also add to confusion; wikis can become challenging to

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[52] "What Links Here," in *Wikipedia*, accessed March 7, 2021, https://en.wikipedia.org/wiki/Special:WhatLinksHere.

traverse as they increase in scale, since there is typically no built-in way to view the interconnections across many pages and links.

Some researchers recognized the limitations of the design of wikis in their default state and created wiki extensions, which users could integrate into their wikis to combat these limitations. For example, one wiki extension attempted to deal with the common experience of "getting lost in hypertext," mentioned at the outset of this chapter. The tool, called *WikiTrails,* created graphical representations of a users' path as they navigated a wiki, allowing users to see a web-like chart of the pages that they had moved through, and the links that they had followed along their way. The tool was designed such that educators could create trails and give them to their students in order to provide additional scaffolds when recommending areas of research in a large database.[53] While the openness and extendibility of wikis broadly allowed for these types of experiments in adding additional layers of information and context for viewers, tools which changed core functionality of the wiki model rarely found any wide adoption, likely because they required additional time to install and learn, and did not come with examples for educators to use in classrooms.

Furthermore, wikis typically present one single representation of information on a page, which hides the way that the page has changed over time. When collaboratively editing a page on a Wiki, only one edit is accepted at a time; wiki pages only show one "truth," and while the reader typically knows that there is often a social history to the content, that history is obscured. The edit history of how a wiki page has evolved is typically presented within a separate view rather than part of the primary document itself, if it is visible at all. This limitation creates

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[53] Silvan Reinhold, "WikiTrails: Augmenting Wiki Structure for Collaborative, Interdisciplinary Learning," in *Proceedings of the 2006 International Symposium on Wikis*, WikiSym '06 (New York, NY, USA: Association for Computing Machinery, 2006), 47–58, https://doi.org/10.1145/1149453.1149467, 55.

significant challenges when trying to evaluate student contributions, which will be discussed in later sections of this chapter.

Furthermore, when viewing wiki pages, a user is not able to see commentaries or annotations on top of an entry in the way that earlier hypermedia forms allowed. With the lack of this feature, wikis also obscure the identities of the creators and editors of each piece of content that are added to the wiki. When working in classrooms, the obscuration of authorship became an issue. Across many studies involving wikis, educators set up additional wiki pages which could be used as discussion forum sections to recommend changes to each other, since editing on wikis directly affected the original content. In these forums, learners would need to re-describe sections that they recommend changes to, rather than make annotations directly on the writing itself.[54]

2.4 Bringing Wikis to the Classroom

With a growing optimism about the wiki as an emerging tool, there were many lofty learning goals prescribed to wikis almost as soon as they began being used in classrooms. Educators and researchers that had already been advocates for constructivist learning with digital tools saw clear overlap between the potential goals of collaborative learning experiences and various aspects of the design of wiki platforms. Some educators argued that the act of using a wiki in the classroom, both as a reader and a contributor, would offer a path to developing

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[54] Andrea Forte and Amy Bruckman, "Constructing Text: Wiki as a Toolkit for (Collaborative?) Learning," in *Proceedings of the 2007 International Symposium on Wikis*, WikiSym '07 (New York, NY, USA: Association for Computing Machinery, 2007), 31–42, https://doi.org/10.1145/1296951.1296955.

necessary skills involved in being a lifelong learner, while simultaneously embodying aspects of personal empowerment and communication between peers.[55]

There are two aspects of wikis' design that particularly appeal to the constructivist approach. Like earlier hypermedia models, wikis allow users to organize and present content in a way that does not prescribe a set organizational form and can allow for organic growth. Wikis use pages as nodes, which can refer to each other to form a network, and does not need to be predetermined. This offers the potential for students to build out wikis by adding and linking new pages as they follow self-directed learning. Furthermore, the collaborative aspect of editing wikis is very appealing from a social constructivist perspective; the act of negotiating knowledge through the co-editing of a page directly relates to how learning is described to occur from the constructivist framework.[56]

Between 2004 and 2006 alone, educators and researchers proposed and developed a wide variety of learning experiences which brought Wikis into classrooms with different subject areas, contexts, and learner maturity levels. Wikis offered an opportunity to explore how knowledge creation could occur in groups with much more accessibility and with groups of much larger scales than had been possible before. The fact that wikis did not need specific software installed to be able to run, or expensive additional custom hardware (like the previous examples of the 1980s) massively lowered the technical barrier not only to getting classes started with working with wikis, but also for thinking about collaborations that could occur at much larger scales.

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[55] Alain Désilets and Sébastien Paquet, "Wiki as a Tool for Web-Based Collaborative Story Telling in Primary School: A Case Study" (EdMedia + Innovate Learning, Association for the Advancement of Computing in Education (AACE), 2005), 770–77, https://www.learntechlib.org/primary/p/20175/.
[56] Joyce Seitzinger, "Be Constructive: Blogs, Podcasts, and Wikis as Constructivist Learning Tools," *Learning Solutions E-Magazine* 31 (2006): 1–12.

Educational wikis can take a variety of different forms, and can also involve different degrees of engagement, or levels of collaborative activity. Ta-lElhasid and Meishar (2006) break down the modes of collaborative behavior on wikis into four general categories. *Sharing* is the lowest-level collaborative behavior, where all students work in the same shared wiki, but each develops their own writing completely independently. Other students might be exposed to each other's work and learn from it, but learners do not interact with their peers' work directly. *Cooperative* behaviors on wikis still primarily involve individually created work, but in this case individual assignments are merged into a final project by linking all the finished pages together at the end.

Using wikis with a *collaborative* model implies learners working together on individual wiki pages, synchronously or asynchronously. Working collaboratively, learners can take on a variety of different roles on the wiki, acting as writers, editors, researchers, outliners, etc. This model more directly uses the affordances of the wiki environment, with its ability for collaborative document editing and branching page linking. *Peer assessment* is another collaborative model which does not make use of the wiki's affordances, and is not situated during the learning process itself, but is nonetheless a collaborative format that classrooms can use with wikis. While wikis don't typically allow for commenting or annotating on a page without directly editing it, some classrooms have used peer assessment in the discussion forums on a wiki as an opportunity to provide feedback.[57]

However, while students were expected to collaboratively edit wiki pages simultaneously, they often would run into several related technical challenges. Unlike many contemporary tools which offer a fully synchronous environment for editing where users can

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[57] Edna Tal-Elhasid and Hagit Meishar-Tal, "Models of Activity, Collaboration and Assessment in Wikis in Academic Courses," in *Distance and E-Learning in Transition*, 2013.

watch other users write in real-time, wikis require users enter an edit mode and upload their

changes to the full document only once they have finished drafting. Thus, while multiple users

can be "editing" a document (or wiki page) simultaneously, uploading edits simultaneously can

cause merge conflicts, especially when many users are collaborating at once. Negotiating these

types of merge issues can become a significant social challenge in the classroom, particularly for

younger sets of students.[58] Said Hadjerrouit discusses issues when learners are simultaneously

editing a wiki page, describing how when multiple users work on a section at once, they often

end up writing over each other's work. Hadjerrouit describes the need for developing a page-

locking mechanism such that a learner can claim an area of the wiki to work on it without issue

and can unlock the section when they are finished.[59] However, such a locking system would

intentionally limit the amount of real-time collaboration that can occur on wikis, when students

are "safeguarding" collective pages or sections while they edit them.

2.4.1 Models for Using Wikis for Learning

Unlike CSILE and Intermedia, which were developed with specific learning applications

in mind, wikis are a more general framework, which users can utilize as platforms for imposing

models of learning. What are some of the models for developing collaborative learning

experiences using wikis that educators and researchers developed? What types of environments

did these applications create? As a flexible tool that can be potentially employed in the

classroom setting, wikis were used for a rapidly increasing variety of activities to support

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[58] Lyndsay Grant, "'I DON'T CARE DO UR OWN PAGE!'A Case Study of Using Wikis for Collaborative Work in a UK Secondary School," *Learning, Media and Technology* 34, no. 2 (2009): 105–17.
[59] Said Hadjerrouit, "Investigating Technical and Pedagogical Usability Issues of Collaborative Learning with Wikis," *Informatics in Education* 11, no. 1 (April 15, 2012): 45–64, https://doi.org/10.15388/infedu.2012.03.

learning in the years following the popularization of the Web 2.0 model. Mark Phillipson developed a taxonomy of five main types of wiki usage in the classroom. Three of the five wiki types in his taxonomy represent most of the typical wiki usage, and while distinct from each other, they contain some overlapping features.[60]

The first is the *resource wiki*: a collaborative knowledge base where learners contribute their knowledge to an expanding encyclopedic resource. Resource wikis are typically more outward-facing, meaning that they are not intended to contain in-progress documentation of learning processes, but instead function as a knowledge base that could be legible and potentially useful to external readers beyond the class. Students might be assigned to creating specific article-style entries, integrating text and images, and attribution to cited articles. These types of wikis are intended to perform like Wikipedia, as a resource containing reliably sourced information.

One representative model of a classroom-style resource wiki is the M/Cyclopedia project, a notable early usage of wikis in the classroom context, the results of which were shared as part of the International Wiki Symposium in 2005. The project was developed by Dr. Axel Bruns and Dr Sal Humphreys as an early experiment in employing social constructivist pedagogical tools to enable university students to develop advanced information communication technology (ICT) skills. Working throughout the semester, students built annotated bibliographies on a new media topic, and then formed collaborative groups to create major wiki entries on communally chosen topics. Students from each group then extended their collaboratively written major entries by adding smaller sub-topical entries, which they connected both to the major entries, as well as to each other's writing across groups. The entire encyclopedia-style new media wiki was published

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[60] M. Phillipson, "Wikis in the Classroom: A Taxonomy," *Wiki Writing: Collaborative Learning in the College Classroom*, January 1, 2008, 19–43.

on the wider web at the end of the semester.[61] The M/Cyclopedia wiki systems were used for more than writing finished pieces; students also set up discussion forums within the wiki itself. The groups also used the wiki revision history function to track the changes and degrees of contributions made by each group member on the collaborative pages. Bruns and Humphreys describe one of the primary affordances of this model to facilitate small-group user interactions which simultaneously benefit the whole class as particularly useful in large university courses, where students can build a substantial resource using the combined efforts of the large cohort of peers.

One related genre of wiki usage is the *presentation wiki.* This type of wiki is used to document in-progress learning and knowledge in a format that is less outwardly facing, and more focused on its use for the learners, like a "self-conscious" resource wiki. Unlike resource wikis, which typically use the impersonal encyclopedic tone of voice, presentation wikis have more room for individuals to use their own writing styles and tones. While learners using presentation wikis will link their pages and ideas together, it is more likely to be intentionally apparent who developed each page on the wiki to assess the contributors. Presentation wikis are also more likely to have segmented areas where contributors work individually or collaboratively in private spaces, while finished work will be added to the publicly accessible areas upon completion.

One main example is using wikis for "co-writing," as an opportunity to bring students away from the traditional solitary mode of written work to collective writing processes, which not only offers opportunities to practice reading and writing, but also involves critical thinking and reflection. For example, Dymoke & Hughes (2009) developed a collaborative wiki for pre-

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[61] Axel Bruns and Sal Humphreys, "Wikis in Teaching and Assessment: The *M/Cyclopedia* Project," in *Proceedings of the 2005 International Symposium on Wikis*, WikiSym '05 (New York, NY, USA: Association for Computing Machinery, 2005), 25–32, https://doi.org/10.1145/1104973.1104976, 31.

service English teachers, where they collaboratively and individually worked on poetry projects. Throughout the course of the study, they examined how the pre-service teachers intervened in each other's creative writing, and how their poetry changed through these collaborations. Some participants understood the affordances of wikis and used them to work collaboratively with others, while others understood the potential of wikis as a collaborative medium, but nonetheless stayed in their own corner of the wiki where they wrote individually. The pre-service teachers mostly used the collaborative aspects of the wikis to share in-progress work and provide feedback as part of the co-writing process.[62]

There are also *illuminated wikis,* where students actively mark up, analyze, and transform an existing body of source material. For example, when given a specific text to analyze, an educator can create a primary source page for the text itself, and students can select chunks of the text, link it to their own pages, and write their own annotations and analyses of the text. When developing this type of activity in a class working on eighteenth and nineteenth century poems, students would choose specific words or phrases from the primary text, actively "staking ground" in the text, by linking the words and phrases to their own analysis pages. Thus, the shared primary text becomes illuminated and enlivened by the full class's set of annotations and explanations.[63]

How did students engage with these various models of using wikis in the classroom? Perhaps unsurprisingly, several common student behaviors can create significant difficulties with using wiki-based learning activities to their full extent. For example, procrastination vastly

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[62] Sue Dymoke and Janette Hughes, "Using a Poetry Wiki: How Can the Medium Support Pre-Service Teachers of English in Their Professional Learning about Writing Poetry and Teaching Poetry Writing in a Digital Age?," *English Teaching: Practice and Critique* 8, no. 3 (December 2009): 91–106.

[63] M. Phillipson, "Wikis in the Classroom: A Taxonomy," *Wiki Writing: Collaborative Learning in the College Classroom*, January 1, 2008, 36.

reduces the possibility for collaboration. When rushing to complete their work against a time crunch, students are much less likely to take the time to reflect on each other's work or thoughtfully cross-reference between wiki pages and are much more likely to focus on writing their own content. Working with limited time, learners also aren't able to give detailed in-progress feedback to their peers. Many of the research papers using collaborative wikis had students develop wikis over the course of the semester with specific intermediary goals and deadlines to intentionally mitigate these behaviors.

More broadly, several research studies identified that very few students would edit the material on others' pages. In a 2005 piece titled "Is there a space for the teacher in the wiki?" Lund and Smørdal assert that an important role for teachers using wiki environments is to explicitly design learning activities, or "genuinely collective tasks" which pushes learners to collaborate on editing pages. In their research study, when activities themselves did not demand collaborative behaviors, the students typically worked only on their own areas of the wiki.[64]

In 2013, Justin Reich added further evidence to understand collaborative behavior in classroom wikis by developing a method for examining and evaluating the edit history of wikis to be able to classify the types of collaborative behavior that were occurring on education-related wikis, using taxonomy of collaborative behavior: concatenation, copyediting, co-construction, commenting, discussion, scheduling, and planning. The technique uses a method called "large-scale content analysis," which involved gathering and analyzing a massive number of edits from across 406 available education wikis.

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[64] Andreas Lund and Ole Smørdal, "Is There a Space for the Teacher in a WIKI?," in *Proceedings of the 2006 International Symposium on Wikis*, WikiSym '06 (New York, NY, USA: Association for Computing Machinery, 2006), 37–46, https://doi.org/10.1145/1149453.1149466, 44.

In the piece, Reich identifies a crucial issue with the methods by which wikis (among other educational technologies) are typically studied: having involved researchers examining classroom behaviors, often with limited sample sizes of single or small numbers of classrooms. In these conditions, the researcher either takes an active role in setting up the wiki with the educator, or the educator is already familiar and excited about working with the tool. Reich calls these situations "hot-houses," and argues that they are not representative of the ways that an average classroom would use the tools, without the aid of a researcher and added excitement of an educator who has chosen to participate in something novel. Indeed, this is the argument for large-scale content analysis; rather than examining a single classroom during a limited study, a researcher can look across the behaviors of a large range of types of classrooms to find trends in students' behaviors when engaging with the tool.

Reich suggests that wikis tend to be collections of individual constructions, rather than an intensive participation in collaborative knowledge-building. In these cases, the wikis act as a shared repository for collecting knowledge and writing from individual students, more than a platform for facilitating substantial collaborative behaviors and modes of participation. Why does collaboration not typically occur? Earlier literature that took critical stances on classroom uses of wikis suggests that the format of wikis themselves are incompatible with traditional educational models. Nina Dohn (2008) argues that integrating Web 2.0 technologies in education is a process of integrating certain practices, more than it is a matter of integrating new types of tools. The tools themselves, she suggests, are "*relatively* unimportant; it is the skill-relative affordance it poses for the agent in a given context that matters."[65] By this, she argues that skills themselves do not emerge merely upon engaging with a new type of tool; the way a learner uses

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[65] Nina Bonderup Dohn, "Web 2.0: Inherent Tensions and Evident Challenges for Education," *International Journal of Computer-Supported Collaborative Learning* 4, no. 3 (2009): 343–63, 347.

a new tool is entirely dependent on the skills that they have, or new skills that they are taught in order to use the tool itself. When it comes to Web 2.0 technologies like the wiki, the types of skills and behaviors that are required include distributed authorship and ownership, multi-way communication, and an open-ended approach to activities and projects.

2.4.2 Evaluative Challenges

One additional difficult challenge with integrating wikis into classrooms is a friction between a widespread culture of individual assessment and the collaborative practices that were intended with the use of wikis in classrooms. This friction played out both with students' own perceptions and notions about appropriate ways to contribute to shared wikis, as well as challenges for teachers with grading students individually. For example, one 2007 study involved a year-long experiment using wiki tools to support constructionist approaches where high-school environmental science students collaboratively wrote science articles in a MediaWiki-based platform which they called *Science Online.* One of the takeaways from the project was that "students were socially unprepared to use the wiki in a collaborative fashion." In many cases, these involved dealing with edit conflicts with students writing over and erasing each other's work, or being uncomfortable working in the same space at all.[66] These social challenges are commonplace across many of the early research studies on collaborative wikis practices in classrooms; students' responses ranged from describing being able to better perform the learning

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[66] Andrea Forte and Amy Bruckman, "Constructing Text: Wiki as a Toolkit for (Collaborative?) Learning," in *Proceedings of the 2007 International Symposium on Wikis*, WikiSym '07 (New York, NY, USA: Association for Computing Machinery, 2007), 31–42, https://doi.org/10.1145/1296951.1296955, 39.

tasks individually or were otherwise reluctant about negotiating in these shared spaces was a commonality that was regularly mentioned. [67]

Another important challenge for educators was evaluating student work. When trying to evaluate students by examining wiki pages that *had* been collaboratively edited, wikis typically only provide a linear "page history" with which someone can gain a sense of how pages were added. Judging each students' overall contributions using this linear history on each specific page is an incredibly laborious and unintuitive task.In the *Science Online* project, the educator running the activity and grading the students faced substantial trying to parse students' working, leading the researchers to suggest that "not only did cultural and institutional barriers stymie collaboration but the *design of the collaborative tool itself* contributed to resistance among the students and among the teacher."[68]

There were efforts to deal with these evaluation challenges using wikis throughout this period. For example, in 2009 G. Trentin attempted to codify a methodology for managing evaluation in co-writing contexts based on a combination of objective data regarding the number of messages sent, the individual volume of writing contributed to the wiki, as well as subjective which included teacher evaluation as well as peer evaluation of the student's contributions. Individual contributors were also automatically evaluated by how many links each student made between their own individually crafted page clusters and the clusters created by their peers. While these models are useful for tracking student participation, the authors nonetheless make

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[67] Irina Elgort, Alastair G. Smith, and Janet Toland, "Is Wiki an Effective Platform for Group Course Work?," *Australasian Journal of Educational Technology* 24, no. 2 (2008);
Will Wai Kit Ma and Allan Hoi Kau Yuen, "A Qualitative Analysis on Collaborative Learning Experience of Student Journalists Using Wiki," in *International Conference on Hybrid Learning and Education* (Springer, 2008), 103–14;
Tony Carr et al., "Weathering Wikis: Net-Based Learning Meets Political Science in a South African University," *Computers and Composition* 24, no. 3 (2007): 266–84.
[68] Forte and Bruckman, "Constructing Text," 39.

the conceit that high degrees of connectedness of various clusters are not a sure metric of quality; sometimes high-quality clusters might not easily connect to other areas of a given wiki.[69]

2.5 Conclusion

Looking across the design and application of wikis in classrooms, it becomes apparent that wikis are not merely a matured version of the collaborative hypermedia learning tools discussed in the previous chapter but carried their own set of design differences and drawbacks as well. Yet, while the wiki model may not have grown into a classroom norm during this time, the decade-long period in which wikis were most readily studied in learning contexts contributed to more sophisticated design methods and vocabulary regarding how to situate digital collaboration.

It is worth acknowledging that unlike the tools examined in the previous chapter, very few wiki-based classroom research studies described significant technical challenges involved in getting learners comfortable with the basic wikis. The fundamental concepts behind using hypertext and growing accustomed to the basics of engaging with computer software were likely already familiar to learners from previous engagement with internet platforms. Surpassing this initial onboarding challenge was a significant step towards making these platforms accessible, and this cultural shift towards a general comfortability with hyperlinks and networked databases of media is certainly encouraging when imagining future possibilities for hypermedia knowledge organization tools in classrooms.

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[69] G. Trentin, "Using a Wiki to Evaluate Individual Contribution to a Collaborative Learning Project: Wiki Use in a Collaborative Learning Project," *Journal of Computer Assisted Learning* 25, no. 1 (January 16, 2009): 43–55, https://doi.org/10.1111/j.1365-2729.2008.00276.x, 49.

Indeed, the patterns of challenges across this wiki-based research typically emerged when learners bumped up against the limitations of the tools themselves, or when the activities were at odds with students' expectations about the culture of the classroom. For students, these frictions often involved challenges regarding assessment, as well as navigating (often unfamiliar) social processes of collaboratively planning networked projects, conducting joint research, and editing together. This is quite different from the previous tools, where students had to simultaneously become comfortable with unfamiliar pedagogical practice as well as computers that they had never tried before. Turning to hypermedia knowledge organizations that have emerged in the years since the popularization of the wiki, one can now consider how recently emerging tools encounter the challenges described in the chapter.

Emerging Spaces for Classroom Hypermedia: Digital Gardens and Learning Dens

3.1 Introduction

In the years since the popularization of the wiki and the mass adoption of the internet more broadly, there has been a new wave of hypermedia knowledge organization tools. Many of these tools draw upon design patterns from both eras that have been discussed previously, even as they are designed to be relatively open and flexible and without any explicit design for particular learning contexts. Why has there been a recent resurgence of these types of tools? What commonalities are shared between them? And based on what has been learned from the previous eras of hypermedia knowledge organization tools, how might these tools find a fit into learning contexts?

In seeking to answer these questions, this chapter will first consider two case studies of these contemporary hypermedia-oriented tools which are designed for collaborative research and knowledge-building practices. I have chosen two platforms as cases which are representative of the variety of types of tools emerging in this space because they have quite different designs while still demonstrating several common overlapping design decisions between many of these platforms. The first platform discussed in this chapter is called Are.na, which is an example of a hypermedia knowledge organization tool which emphasizes *socially collecting* and organizing

knowledge and is more focused on gathering and sharing content than being the environment in which one creates it. The second is a tool called Roam Research, which emphasizes *networked writing*, and is more creation-oriented than focused on inviting novel social interactions. Despite these differences, each of these tools build upon aspects from the types of hypermedia knowledge organization tools that have been discussed in the previous two chapters and carry overlapping design decisions. This chapter will examine three common design features of these platforms in more detail to illustrate some of the broad trends in these recent tools: a bias towards smaller nodes of connectivity, the notion of back-linking, and the importance of creating serendipitous discovery.

Turning from the specificities of these new platforms, I will shift to discuss a potential avenue for using hypermedia knowledge organization tools in classrooms. This will bridge examples of the affordances of the newer types of tools discussed in this chapter with potential pedagogical applications that will account for the frictions in classroom applications of these tools that were discussed previously. This involves understanding a model of using hypermedia knowledge organization tools called *digital gardens* and considering how this model can be effective in the classroom context. I then describe a case study using Roam Research in a 7th grade classroom which draws from the digital gardens model to create a networked environment for social-emotional learning and reflection.

3.2 A New Generation of Hypermedia Knowledge Organization Tools

A new generation of hypermedia knowledge organization tools has been growing since the mid-2010s, tools which combine many of the design features of the previous two moments. Much like tools examined in the previous chapters, the emergence of this new generation of

platforms cannot obviously be pinpointed to any one single factor. In part, this new generation of tools has grown in parallel to the explosion of the broader genre of knowledge organization and workplace productivity software designed for more productive note-taking that began growing in the mid-2010s. Throughout the 2010s software tools to foster increased workplace productivity and knowledge management practices saw new mass adoption with the popularization of Slack and Evernote.

By the mid-2010s, developing feature-heavy products in this landscape became increasingly lucrative. For example, one networked knowledge organization tool called Notion markets itself as an enterprise-oriented collaborative knowledge management platform which combines notes, wikis, databases, calendars, and reminders. The company describes the tool as an all-in-one space to combine notetaking with knowledge management and project management. After continuing to grow for years, Notion received a $2 billion valuation in April of 2020, likely bolstered by the shift from the office into the home as millions of workers began quarantining during the COVID-19 pandemic.[70] The potential to strike gold in the notetaking and productivity space is implicated in a renewed focus on developing knowledge-organization tools that experiment with new features, including interactions that *feel* new which borrow from wikis and earlier hypermedia models.

We can now turn to two small case studies of contemporary hypermedia knowledge organization tools to consider some of the broader design considerations of this current generation of tools. The first tool is called Are.na, a platform for organizing bits of media into collections, and letting those collections intermingle. The creators of the platform often describe

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[70] David Jeans, "Buzzy Work App Notion Hits $2 Billion Valuation In New Raise," Forbes, accessed April 5, 2021, https://www.forbes.com/sites/davidjeans/2020/04/01/buzzy-work-app-notion-hits-2-billion-valuation/.

it as a tool for doing research online, "like the kind of research you are doing when you find yourself going down a Wikipedia hole."[71] Are.na is more specifically oriented towards social organizing and knowledge-building, and while it has a "feed" like many other social media platforms, it explicitly does not operate on an ad-based model, its feed is entirely chronological rather than employing algorithms to rank and prioritize content. While Are.na does employ social elements like "following" users and writing comments, Are.na intentionally does not show users' follower counts or include interactions like the "like," which have become emblematic of large-scale social media platforms.

Parallel to Are.na's relatively abstract self-description, the designers of Roam Research call their platform a "tool for networked thought."[72] Like Are.na, Roam (as it is often abbreviated) is not explicitly designed for one specific type of work or type of user. However, the tool is broadly marketed to "knowledge workers," like researchers, writers, developers, designers, product managers. Roam began opening its initial beta in late 2019, at a time of a rapid proliferation of other productivity tools and note-taking applications. Unlike Are.na, Roam Research automatically generates a new page for each day, called the "Daily Pages." The Daily page is the automatic landing page when a user opens Roam. Taking notes on these daily pages encourages users to link ideas to when they are working on them and can then embed those ideas directly onto other pages later on, or simply make linked references to other pages that are referenced by notes on the daily page.

[71] Charles Broskoski and Laurel Schwulst, "Charles Broskoski on Self-Discovery That Happens Upon Revisiting Things You've Accumulated Over Time," 2017, https://thecreativeindependent.com/people/charles-broskoski-on-self-discovery-upon-revisiting-things-youve-accumulated-over-time/.
[72] "Roam Research – A Note Taking Tool for Networked Thought.," accessed January 30, 2021, https://roamresearch.com/.

While these two hypermedia knowledge organization tools are quite different from each other, comparing some of their overlapping features and design decisions will illuminate some of the broader trends that emerge across many of these platforms. Some of the broad trends between them include the wiki-like model that they are more generalized tools that are not explicitly designed for education, yet make significant claims to assist thinking and learning. Like the mid-2000s wikis, these recent hypermedia knowledge organization tools are primarily browser-based, and are synchronously editable, meaning that users can see others' changes in real-time.

3.2.1 Bias Towards Small Nodes

Like the tools from the 1980s, this emerging generation of hypermedia tools emphasizes the importance of multi-contextuality; where one idea can simultaneously link to multiple places, a design pattern that was present in Intermedia and CSILE. With this notion of multi-contextuality, the current generation prioritizes creating and connecting smaller "nodes" of information – individual ideas, or bits of media. These nodes are smaller than the wiki, where "page" was the individual node that could link out to other pages, which would often include a combination of a significant amount of text and images.

In Are.na, the two underlying metaphors are channels and blocks, where channels can act like folders, as containers to hold many blocks which are arranged in a grid. A *block* is a generic term to represent any kind of media – text, images, links, videos, or other channels. Each block can live in multiple channels simultaneously; by clicking on a single block, a user can see all the channels that the block is connected to, or all of the different contexts in which the block lives. An example will make this clearer: a user might have one channel called "Learning Tools" that holds a link to the Wikipedia article about HyperCard. The user has also connected the same

HyperCard Wikipedia page to a different channel of "Software that uses Card Metaphors." By clicking on the block for the Wikipedia article, a user can see both contexts in which the block lives and might jump from one to the next. A user's channels themselves are not hierarchically organized. Rather, channels can act as blocks that live within other channels. In this way, a user can explore their own or others' collections not only through the cards contained within them, but by moving through and across to other channels.
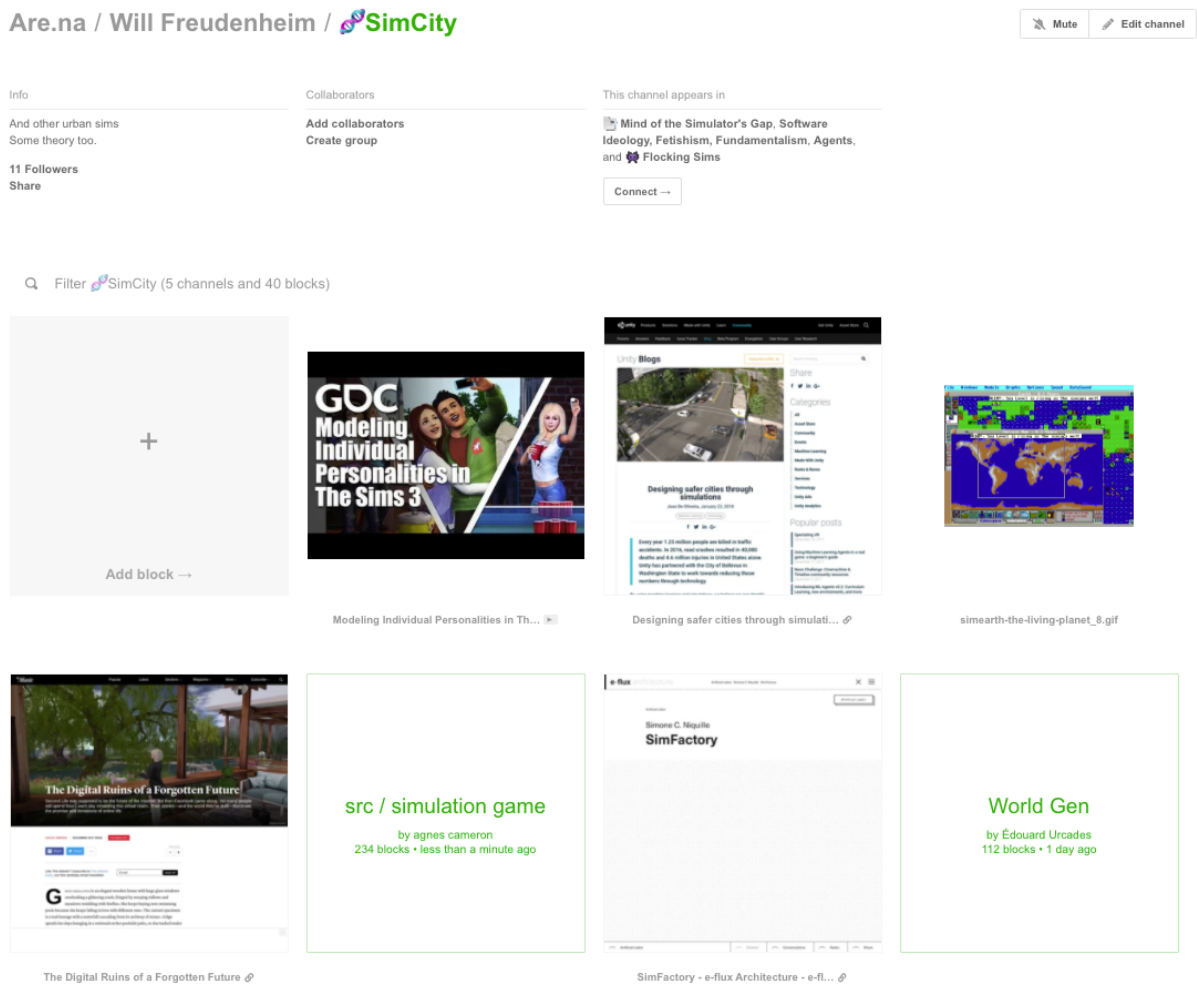
An example of an Are.na channel with blocks that contain images, text, links to websites, or other channels. Each one of the rectangles in the grid is one "block."

When using Roam Research, an individual page might look much like a typical wiki, to the degree that there are pages with text and images, with the text containing hyperlinks that let the user jump from one page to another in the database. A user creates links to other pages by double-bracketing the surrounding words of a page that they want to link to. For example, while writing a paragraph of notes, a user might create a page by typing the word [[Link]], which then becomes a clickable button which takes the user to a page titled "Link." Unlike the wiki, where each page functions as the lowest-level node that can be hyperlinked together, in Roam, any individual bullet point on a page is its own node.

Like Are.na and several other hypermedia tools, Roam also uses the "block" as its metaphor for the individual node. Each node, or "block" is given an ID code when it is created, so that a user can hyperlink from individual blocks to other blocks. What this primarily allows is letting one single block live in multiple places at once by embedding the block ID on multiple pages. This can be useful in many ways: a user might be taking notes on a page called "Reading Notes," and have some commentary that they think is particularly interesting. The user can then embed that same block on another page called "Essay Ideas," which holds several different thoughts that are references from reading notes pages from many different texts. The user might then use the block reference again on another page where they are writing out the full essay. Allowing the single block of text live in multiple places enables the user to make changes to block in any of the locations that it exists in, and those changes will be reflected in all the other places. If the user expands or refines the idea, that idea will be refined in the reading notes as well as the essay itself. In addition, when a block is used in multiple simultaneous locations, a button appears next to the block itself which enables a user to see and jump to any of its various homes.

Knowledge Building

- References
    - [[tarchiKnowledgeBuildingKnowledge2013]] - Knowledge Forum
    - [[reichConfrontingPaucityCollaborative2013]] - discusses knowledge building
    - [[scardamaliaComputerSupportKnowledgeBuilding1994]] - some CSCL context
    - From ETEC510 Wiki
- Knowledge Building
    - Highlights from ETEC510 Wiki
    - [[Collaborative Knowledge Building]]
        - Introduced by Scardamalia and Bereiter (1994) scardamaliaComputerSupportKnowledgebuilding1994 - study of learning at school
        - A necessary condition for collaborative knowledge building is that learners bring individual prior knowledge into the learning situation and clarify differing views and opinions in the course of interactions. This new knowledge emerges neither naturally nor spontaneously and needs to be fostered based on understanding of how new knowledge emerges in social interactions.
- In recent years, five identifiable elements of change—robust new possibilities and catalysts— have arisen which contribute boldly to our ability to deliberate the many alternate futures of technology in education:

    #quote [[christalSchoolsKnowledgeBuildingCommunities2001]] 6

A sample Roam Research reference page on "Knowledge Building." Bracketed pages link out to pages for specific text, as well as concepts. Each bullet point is its own "block" which has a unique identifying code.

3.2.2 Bi-directional Linking ("Backlinking")

The most familiar type of interaction with links involves clicking a link which takes the user into a completely new place. This is a typical "one-directional" link, where following the link points to a new place. *Bi-directional* links, on the other hand, go both ways; a link not only uses a piece of media to point the user to a new place, but also points back to where it was linked

from. In hypermedia knowledge organization tools, pieces of media that are "linked" to many other places can themselves show all those linked locations. To take a literary example to make this concept clearer, imagine when reading a research paper on the computer and coming across an interesting quote that has a reference attached to it. Following that reference in a standard one-directional way would point the reader back to the original source text. However, in a bi-directional system, the source text would "know" all the different places that this quote had been referenced, so clicking on the quote would not only point to the source but could link to all of the other papers that might have referenced it. Building elaborate networks of these bi-directionally linked documents is one the earliest hypermedia concepts and was a crucial aspect of Ted Nelson's original vision for hypertext systems.[73]

Both Are.na and Roam Research provide useful examples of how this design pattern is incorporated into contemporary tools. The designers of Are.na make an emphasis to prioritize *multi-contextuality,* or the notion that meaningful thinking and idea generation can happen when ideas can carry multiple labels and can live in multiple places at once.[74] Clicking on any block will open the block up into a preview window, where the user can see all the other channels into which the block is connected. Any individual block can potentially connect to hundreds of different contexts, in a way that the channels themselves can function like tags. Are.na uses one central database to store all these connections, such that anything connected publicly can be shared with the entire community of users on the platform.

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[73] Theodor H. Nelson, "Literary Machines: The Report On, And Of, Project Xanadu, Concerning Word Processing, Electronic Publishing, Hypertext, Thinkertoys, Tomorrow's Intellectual Revolution, And Certain Other Topics Including Knowledge, Education And Freedom," 1981.

[74] One of the main slogans on their homepage is "Are.na puts all your ideas in context."
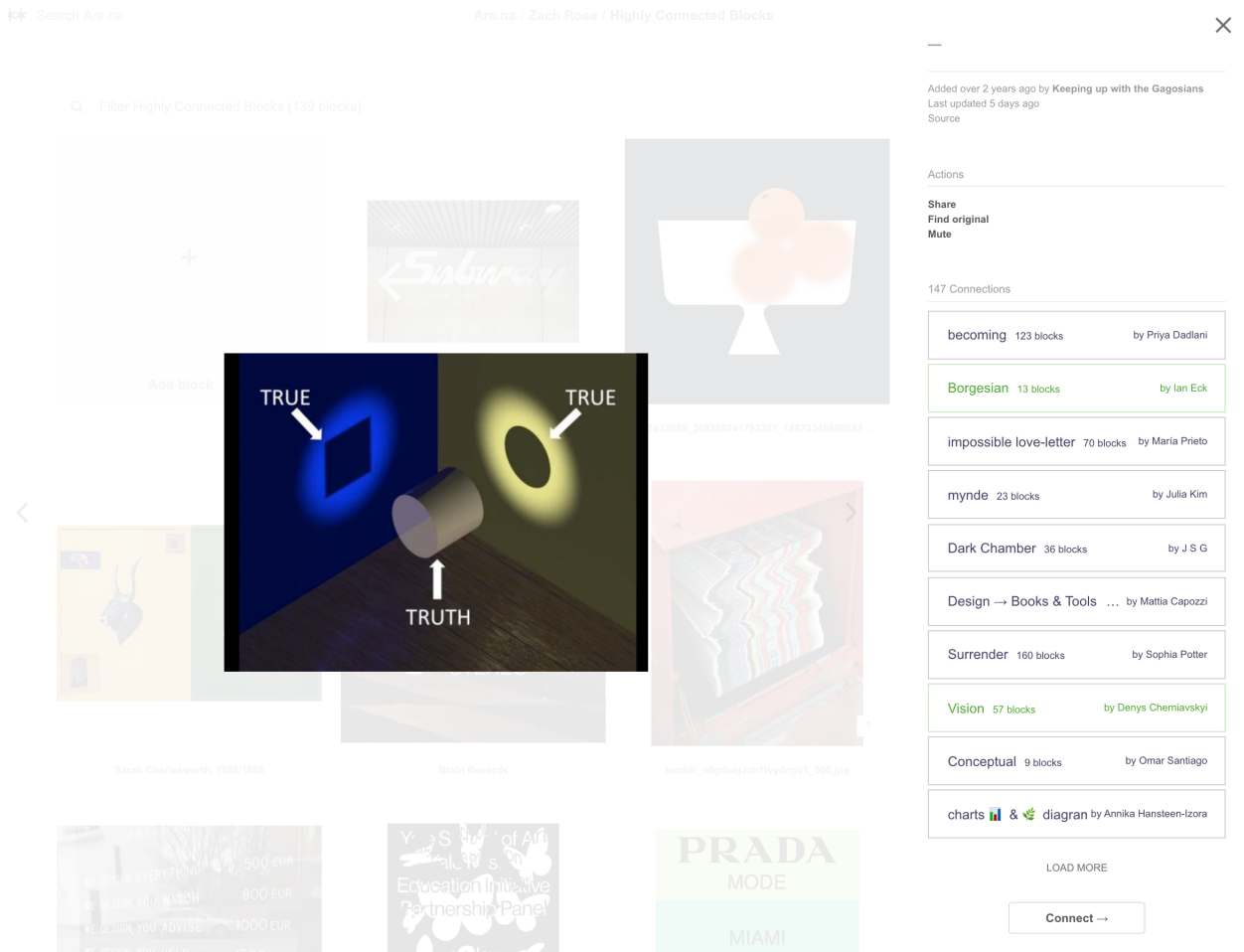
Clicking on a Block in a channel will show all the other channels which that block is linked within. This image is "connected" to 147 different channels, each with varying titles and themes.

In Roam, creating many connections and linkages across pages and blocks can quickly create a web of connections, and both pages and individual blocks allow users to see all the other places where that page or block is referenced. For pages, there are two ways to all the back-linkages that point to any given page. At the bottom of each page in Roam, there are two related foldout areas. The first is a list of "Linked References," which is a list of every other page where the current page is referenced. Any location that points to the current page will be mentioned.

Learning

- Click here to start writing. Type '/' to see commands.

7 Linked References ▼

▸ matuschakHowCanWe2019

▸ kangSpacedRepetitionPromotes2016

▾ Learning Together Online

> **Metadata:**
> - **Tags:** #Article #Learning #Asynchronous #Virtual Education

▾ A: The [[Release Ratio]]: How to Make Use of Everything You Know

> [[Metadata]]
> - **Tags:** #Article #Learning

863 Unlinked References   Link All ▼

▸ April 20th, 2021

▸ April 9th, 2021

▸ April 5th, 2021

▸ March 30th, 2021

▸ March 28th, 2021

▸ March 25th, 2021

▸ March 18th, 2021

▸ March 9th, 2021

Furthermore, in Roam Research, the individual blocks can have multiple backlinks as well. Users can re-use blocks in multiple places, meaning that rather than copying and pasting a

specific chunk of text or an image, that block can be reused in multiple places, such that any changes to the original block propagate as well. A learner writing an essay might have an idea from their class notes that they jotted down, which they can then directly incorporate into a completely different page while writing an essay. That block then shows a number next to it which shows all the different places where it was used, allowing users not only to easily re-use, but also retrace the usage of ideas and information.

3.2.3 Serendipitous Discovery

One final design feature that is common across many of the contemporary hypermedia knowledge organization tools is an emphasis on serendipitous discovery, or the ability to "accidentally" re-find old things that one has added and forgotten about, or to discover new things added by other users. Roam Research and Are.na use different design patterns to offer serendipitous discovery of both old and new information.

On Are.na, this kind of serendipitous discovery is driven by its design as a social platform. One crucial aspect of Are.na is its function as a social network of overlapping communities, where all public connections and channels feed into a centralized database. While users can create and share private channels and work collaboratively in their own corners of the platform, ultimately all publicly shared channels are all live at the same network level. In this sense, clicking on one block and looking at its references will show all the references across the entire platform. This type of public backlinking new and unexpected connections; looking at a block that one has added to a personal channel months before, a user might discover five other new channels that other users have connected that block to, which could point them to other interesting or related materials.

In Roam research, this type of serendipitous discovery is slightly more self-referential. Below the "linked references" dropdown where one can see all of the connections to a given page, there is a second dropdown for "unlinked references," which are all the places where the name of that page is mentioned across the entire Roam database where they do not explicitly link to the page itself. The unlinked references have a "link" button next to each reference, which enables the user to convert the plain text into a link to the page, which then shifts the reference from the unlinked section into the linked section. This offers users the opportunity to make new pages and retroactively see any other places where ideas have already been used. The common use-case for this feature is that a researcher might make a page for a specific name, concept, or phrase, and then discover they have already mentioned that name or phrase across many other readings and lecture notes in completely different previous contexts. This feature becomes a tool to help bring old ideas and thoughts back to one's attention, suggesting that the user re-link and recycle them. In doing so, when the user returns to any of their old writing, they can already be integrated within the entire network of writing.

3.3 Digital Gardens and Learning Dens: New Models for Learning on Emerging Platforms

Drawing on both an understanding of the designs of this emerging generation of platforms and with some knowledge about the classroom frictions encountered in previous two chapters, I turn to consider how these new platforms can be used in contemporary classrooms. I examine a model for creating shared small-scale knowledge networks called "digital gardening," a concept which originated in the late 1990s and has recently gained some resurgence with the growth of networked knowledge organization tools. After describing this general framework, I

offer a case study which applied this model in a 7th grade classroom to support social-emotional

learning during the COVID-19 pandemic and consider how we attempted to create designs

which supported collaborative interactions and shared reflection while avoiding some of the

frictions with hypermedia knowledge organization tools.

3.3.1 Digital Gardens

Digital Gardens are a pastoral-inspired genre of personal websites which has grown in

popularity alongside the recent generation of hypermedia knowledge organization. They are

web-based spaces for sharing networked thinking and writing, are often individually crafted

spaces for documenting and sharing learning by building interconnected systems of writing that

spans multiple themes and styles. The concept originated from Mark Bernstein's 1998 piece

"Hypertext Gardens," where he published a series of hyperlinked web pages which poetically

discussed the idea of how to use the craft of hypertext for deeper exploration and reflection on

the internet. In the piece, Bernstein uses a series of pastoral metaphors to conceptualize how

garden-like digital spaces could create new meaningful ways of sharing and interacting with

knowledge, in what was at that time still an early age of the Internet. He described that these

hypertext gardens aim "neither for the wilderness of unplanned content, nor for the straight rows

of organization."[75] Writing in the late 90s, this initial idea was conceived in an era where the

internet was still relatively undefined, and there were fears that dealing with hypertext at a

massive scale would quickly become unwieldy.[76] This was a moment where web spaces were

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[75] Mark Bernstein, "Hypertext Gardens," 1998, http://www.eastgate.com/garden/Enter.html.
[76] "Hypertext: The next Maintenance Mountain | IEEE Journals & Magazine | IEEE Xplore," accessed April 30, 2021, https://ieeexplore.ieee.org/document/735850.

described in relatedly naturalized language like the "digital frontier" and "ocean of information," metaphors which emphasize both massive scale and endless potential for exploration.

While "gardens" similarly carry this natural overtone, they also offer a set of imagery which Bernstein used to frame his conceptualization of how these virtual spaces could be structured. Gardens are spaces which can grow to be wild when untended but are instead are maintained and curated. They are not necessarily perfectly organized like farmland but be messy and have a variety of intermingling plants. Gardens also have the connotation of functioning as spaces for deep thinking and reflection, spaces where people can sit and read without being interrupted. Writing about his own digital gardening practice, one digital gardener suggests that "the phrase 'digital garden' is a metaphor for thinking about writing and creating that focuses less on the resulting 'showpiece' and more on the process, care, and craft it takes to get there."[77] In this sense, the central notion of the digital garden is that it is less intentionally-oriented towards sharing finished work to an audience, and more an opportunity to offer ideas that are in-progress which can connect to each other, and are periodically updated and changed by their author. Hypertext gardens avoid rigid, regimented structures, with multiple paths that can lead in directions. They are small enough to have known boundaries – not so large as to be impossible for one person to explore. The creator or creators of the hypertext garden "tends" to it, meaning that it is not a static set of ideas, but the ideas represented in it change and are updated.

[77] Joel Hooks, "🌱 My Blog Is a Digital Garden, Not a Blog," accessed March 20, 2021, https://joelhooks.com/digital-garden.

about

- Welcome to my "Digital Garden", inspired by [[Anne-Laure Le Cunff]] and many others. About the [[technology of stian's notes]].
- I'll also slowly capture some details about my workflows and hacks here, beginning with
  - [[Retro concept]]
  - [[HOWTO: Spaced repetition in Roam]]
- Some interesting pages (or see all pages)
  - My notes on the absolutely fascinating [[Awakening From the Meaning Crisis]] series
  - [[Fundamentals of Alexander Technique with Michael Ashcroft by James Stuber (Course Builders series)]]
  - [[Mastering the Game of Allyship with Wendell Brit by James Stuber (Course Builders series)]]
  - [[Sapiens 📙]] (currently part of a book club project)
  - [[The World We Create]]
  - Idea for a "book club platform" [[Project Fluid]]
  - My book notes on
    - [[Deep Work 📙]]
    - [[The Body Keeps the Score 📙]] (processing)
    - [[Atomic Habits 📙]] (unprocessed)
    - [[Attention Is Cognitive Unison 📙]] (unprocessed)
  - Things I'm thinking about
    - [[Three levels of Note taking]]
    - [[E: Ad hoc book clubs]]
      - [[Concrete Book Club Idea]]
    - [[E: Incremental Brainstorming]]
    - [[A: Chinese]]
    - [[E: Textbook design for learning]]

technology of stian's notes

- This site is based on two main technologies. First I take all my notes on Roam, and export the JSON.
- Then I use **roam-export** to process the output. This script is pretty messy, but has a lot of neat features
  - automatically resolve embeds and block-embeds
  - queries
    - (I've got this working, but it's not quite integrated yet)
  - advanced link handling
    - use a heuristic to see where I've added an external URL to a topic
    - for pages that are not part of the export, either convert internal URLs to external URLs, or turn them bold (to distinguish from links that actually go to internal pages with content)
  - automatically determine pages to export
    - right now, it exports all pages linked directly from the about page, as well as any page or block that has the `public` tag. (If the tag is top-level on a page, the whole page is exported, but if I have a block on a daily page I want to export, I can just add that tag, and the whole block+children is exported as a page)
- Finally, I send the output to Gatsby, using a **Aengus McMillin**'s **gatsby-theme-brain** and **Aravind Balla**'s **gatsby-theme-andy**, which gives the nice theme and automatic link preview.
- I have many ideas on how to improve this
  - Commenting, maybe even inline (using **Hypothes.is** or something else?)
  - Tag some pages as blog posts, which get a date, a stream of posts, an RSS feed etc
  - Render highlights (^^) correctly
  - Enable folding of long pages (example https://www.loom.com/share/246622d45cb844559ecfc2543ff1d55c using **react-treeview**)
  - Interlinking with other people's **digital garden**s

Referred in

about
Welcome to my "Digital Garden", inspired by [[Anne-Laure Le Cunff]] and many others. About the [[technology of stian's notes]] . I'll...

about
Welcome to my "Digital Garden", inspired by [[Anne-Laure Le Cunff]] and many others. About the [[technology of stian's notes]] . I'll...

If you think this note resonated, be it positive or negative, send me a direct message on Twitter or an email and we can talk.

If you think this note resonated, be it positive or negative, send me a direct message on Twitter or an email and we can talk.

Digital Garden example by Stian Håklev, sharing a variety of different types of writing including book notes, larger topics that he researchers, general thoughts, and writing about how he works. Uses a multi-column model where following a link opens a new column to the right, so readers can follow threads and find their way back to where they started. "Backlinks" to pages referencing the current page are at the bottom of a column. This example is based on an exported JSON file from a Roam Database.

In recent years, the digital garden metaphor has regained popularity in some corners of the internet that overlap with the users and enthusiasts of contemporary hypermedia knowledge organization tools.[78] While there is a shared community of people interested in exploring this form of creating and sharing work, the subject areas and content of the emerging digital garden spaces is quite heterogeneous, from people sharing reviews of books, to individual thoughts, to smaller blog-like essays, etc. Like the variety of types of writing that occur in these spaces, there also is not one clearly identifiable platform that digital gardeners use to host their work. Given that it is a genre of website often emerging from a slightly nerdier-than-average audience, many of the digital gardeners use hypermedia knowledge organization tools to host and share these ideas, others create their own custom skins and variations on top of these platforms, and some design their own custom websites for sharing ideas.[79] Some gardeners take a more Wiki-based approach and create their own custom code or WordPress plugins for creating connections between their articles. Other gardeners publicly share their Roam Research Graphs or connected webs of Are.na channels and embed them into their own webpages as landing pages for sharing their in-progress thoughts and work.[80] Still others take a more utilitarian approach. For example, one writer named John Nixon created a giant web of interconnected Google Docs which he calls "The Index," for both storing and sharing his ongoing notes on readings and conversations, as well as a significant archive of "Idea Lists."[81] Using the google docs model, Nixon manually adds backlinks to other entries at the end of each document.

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[78] Tanya Basu, "Digital Gardens Let You Cultivate Your Own Little Bit of the Internet," MIT Technology Review, accessed January 9, 2021, https://www.technologyreview.com/2020/09/03/1007716/digital-gardens-let-you-cultivate-your-own-little-bit-of-the-internet/.

[79] Maggie Appleton, an anthropologist and designer offers a useful example: https://maggieappleton.com/garden

[80] Stian Håklev's Roam Research-based Digital Garden (image above) *https://notes.reganmian.net/about*

[81] Jeremy Nixon, "The Index," Google Docs, accessed February 15, 2021, https://docs.google.com/document/d/16GRHrEqy1p_ZrmLWIn0eUW4ELcEzol619pcZjRpCefM/edit?usp=embed_facebook.

3.3.2 A Case Study of Hypermedia Gardens in the Classroom: Learning Dens

How might using this networked digital garden model with emerging hypermedia knowledge organizations systems converge with classroom learning spaces? Digital gardens are a model that can be useful in a variety of contexts. One variation could involve using individually curated digital gardens to share and develop in-progress and ongoing classwork. This model is partially influenced by the *presentation wiki* format, where students document in-progress learning on distributed classroom-scale wikis. For example, a middle-school aged learner in an English class could develop a digital garden to write their homework assignments, essays, and creative work all in one shared space, and could be encouraged to explicitly draw connections between essay work, and their homework, their notes, and other classroom assignments. This type of digital garden is developed by an individual rather than a group, and is more focused on organizing, sharing work, and developing connections between work that a learner has themselves created, rather than inputting knowledge created by others. When thinking about the frictions that this type of system has faced in the past, individually created digital gardens have the benefit of giving teachers a space with which to evaluate students' individual work as they use the system.

However, in shifting to examine a case study involving applying the digital garden idea in the classroom context, I will expand upon an example of the process for creating a shared-class digital garden which incorporates collaboration, using a format called "Learning Dens." Learning Dens are a type of classroom-oriented digital garden, involving creating a series of activities which incorporate using hypermedia knowledge organization tools to support social-emotional learning by helping students create shared artifacts to reflect upon their learning

throughout a moment in time. The seed idea for this model of using a hypermedia knowledge organization tool began during a moment of crisis, when facing a fall of remote and hybrid learning during the COVID-19 pandemic. As I was one member of a small team of people developing this project as a member of MIT's Playful Journey Lab, I will switch registers from "I" to "us" and "we" throughout this case study.

In June and July of 2020, the Playful Journey Lab at MIT held a virtual educator conversation series to hear from Massachusetts-based middle school teachers about their experiences during the COVID emergency conditions from the past spring and the new conditions and challenges that they expected to face in the fall. As a research group engaging with the intersection of play, assessment, and learning, we were interested in considering how teachers could support students to document and communicate their own learning and understanding while schooling-from-home. How might playful engagement and design empower students to feel supported, connected, and part of a strong learning community?

We heard a variety of stories, ideas, and concerns shared throughout these conversations. What particularly stood out from them were two concerns. One was that students returning to school would not have opportunities to share with their peers about how they've been doing and what they've been up to throughout the pandemic and have spaces to talk about positive and negative experiences. And relatedly, many of the teachers that we spoke to expressed a desire to have opportunities to get to know their students as their new classrooms remained online.

Since the beginning of the COVID-19 pandemic, students encountered a variety of situations ranging from serving as a family caregiver, to spending time learning how to make TikTok videos with their siblings, to cooking for themselves for the first time. In considering this variety of new experiences and conditions, "Learning Dens" is an activity series format that was

designed to enable collaborative reflection from across these contexts to support both students and educators to acknowledge all types of learning that continue to happen during these challenging times.

3.3.3 Learning Dens: Classroom Format

Following the conversation series and throughout the Fall of 2020, the Lab partnered with the Mendon-Upton Regional School district in Mendon Massachusetts to run a pilot of an activity series called "Learning Dens" for a class that was shifting between virtual and blended learning settings. Learning dens are run by one teacher during their social-emotional learning (SEL) block, a 45-minute period with a class that meets weekly over Zoom. During each session, the Lab Research group designed and offered the class a playful activity or prompt which would be conducted collaboratively inside of Roam Research. After presenting the activity prompt, the teacher can split the classroom into Zoom breakout rooms with either randomly selected or predetermined mini groups of 3-5 students. Students would spend approximately 25-30 minutes working on their activity, while the educator bounced between breakout rooms to check on the students throughout. The last 15 minutes of the session was reserved for mini groups to share what they have made with the full Learning Den group, and to have a small discussion about the activity.

Prompts for Learning Den activities involved a variety of different kinds of virtual and collaborative "making" which took place in a shared Roam Research graph for the classroom. The activities involved writing, drawing, simple video-making, or taking pictures, which were all incorporated into the database. The activities involved reflecting on experiences throughout the pandemic by telling stories using gifs, creating collaborative playlists, and making a shared

group map by taking pictures of elements of natural surroundings. Across these activities, the intention was that students would come away from the Learning Den activity series with a collection of shared artifacts that capture this moment in their lives, help expand their ideas of what learning is, and foster emotional connection with their peers during a time of isolation.

3.3.4 Learning Den Activity Sample: Collective Timelines

One activity involving creating shared timelines will illustrate the type of collaborative reflection and ensuing conversation that were designed for the Learning Den series. In the timeline-making activity, learners were split into groups of four, and given basic templates with only months noted on it. The students were encouraged to add a variety of types of events and moments to the timeline: small events that were personal, world events, local events relative to where they live, and birthdays. Students could also attach images and videos to the timeline as well. Working in these small groups in breakout rooms, students ended up talking with each other about the events that they added to the timeline as they went, helping to remind each other of different types of things that might be valuable to add.

After spending about twenty minutes working on small-group timelines, the groups then returned to the full classroom-sized group, which had its own empty timeline. From there, all the groups merged all their timelines together into a collective timeline on a new page, where each member added and organized their individual elements. Students used Roam's linked reference feature; rather than copying and pasting a duplicate of each timeline moment, they referenced their original moment in their group timeline, so that when looking across the shared full-group timeline, they could click back on a specific event and see it represented in their small group

timeline as well. Many of the timeline events that were placed on the main list were duplicates across multiple groups, but we asked everyone to keep all the events, even if there were duplicates.

After running this activity in October, there were several interesting questions and trends across the different timelines that came up when looking at the group timeline. Certain months had quite a lot of individual pieces in them, while other months had very few. For example, the Black Lives Matter protests in June and July were such significant cultural events that other smaller-scale personal events seemed intuitively less important to add. In earlier months, many students added a lot of "lasts" – like the last day they had in school in person, the last time they hung out with their friends in person. Following the timeline-crafting moments themselves, the activity opened into a longer discussion about what these months have really felt like for students, both individually and as a group. Students shared experiences about boredom and loneliness as factors in making certain months feel empty, stretching out forever, or taking no time at all.

3.3.5 Designing Activities for Shared Reflection

At the outset of this project the research team began by mapping out what we considered to be important design principles for what would make a good Learning Den activity. We ultimately boiled them down to four principles which we tried to incorporate in each activity. A good Learning Den activity should involve students thinking about each other's perspectives, naturally flow into a conversation or discussion, act as an opportunity to be both creative and goofy and can be returned to and built-upon later.

There were several areas that we needed to be intentionally flexible about due to the changing nature of the situation that was unfolding with the pandemic. For example, we intentionally designed activities that could be completed *both* over Zoom, and in a hybrid classroom setting where students were sharing the same classroom space, but were still kept physically separate from each other.

In conceptualizing the Learning Den as a type of digital garden, an important design feature that we considered at the beginning of this was developing the artifacts created by the activity series not to feel like discrete one-off activities that might use a variety of different forms but ultimately were very disparate. Rather, it was important that the collection of Learning Den activities would feel like a place that could be returned to and explored. For example, thinking back to the digital garden model, the timeline was an activity that could be returned to periodically, and "tended" to. Groups were able to return to their timelines after a few months and update them to the present, and individual students were able to regularly add more details into the group timeline after the initial session.

3.3.6 Using Roam Research as a Shared Workspace for Digital Gardening

To facilitate the Learning Den activities, the classroom is set up with its own database with Roam Research. To our knowledge, this was the first project to use Roam in a primary school classroom context as a collaborative resource, and we were fortunate that the team of developers were interested in our project and gave support and feedback throughout the project.

At its most simple, Learning Dens used Roam Research to create a container to hold pages for the different activities that the classroom followed throughout the semester. While using Roam Research was not imperative to being able to run many of the individual Learning Dens activities, we found that many aspects of the tool's features were aligned with some of our design goals, particularly with creating a synchronously editable virtual space that could hold multiple types of media, allowing students to find overlaps in each other's thoughts and ideas, and could hold having activities that can be built upon later.

We created initial landing pages in the Roam Database which had links to different activities, and personal pages for each of the students. From there, students built out pages on their own. The first activity that students did was going to their own page and adding some info about themselves, which included some writing, adding pictures, and links to videos that they like. One feature of Roam that became particularly important to the students and useful across many of the activities is the notion of making hashtags at the end of a chunk of text or connected to an image. Adding hashtags is a concept that the students were very familiar with from their use of social media platforms like Instagram and TikTok in which they use hashtags quite heavily. In Roam, adding a hashtag creates a whole new page for that hashtag, in the same way that adding double brackets around a word does. Going to that page will show all the different backlinks for the places that the hashtag was used. For example, if several students mention Zoom in their personal, they add the hashtag #ZoomFrustrations, the ZoomFrustrations page will show all the different places that zoom was mentioned.

When students were writing about their personal experiences, they would often add multiple hashtags, even to a small bullet point of writing. Sometimes students would use general hashtags for their emotions, like #sad. These pages could fill up with a collection of different

backlinks from across the different activities, so that people could easily see all the different points at which their peers expressed specific emotions or used shared jokes.

In addition, the Roam Research platform is designed such that students can easily begin creating pages for things other than the activities, which can be as simple as pages for games people are playing, or pages to collect interesting things that they've been looking at online. With this format, the shared virtual space was able to extend beyond the activities themselves and connect to students' interests and experiences. With this in mind, we invited students to take ownership of the virtual space.

3.4 Reflecting on Learning Dens as Digital Gardens

In gathering informal reactions from the educator and students, the participants in the initial pilot study largely conveyed Learning Den activity series as a positive experience to their teacher, who described that the students were "engaged and talking" throughout the activities, with some silliness included along the way. Reading through the students' work, there was clearly collaborative discussion and play that took place during this time, where students would add onto each other's timeline elements or pieces from other activities and attach funny hashtags or images. Students would often nest their own bullets underneath the bullet-point nodes of their peers, to add text or images to comment on or respond to an idea. As a general strategy for learning more about each other at often very serious and socially isolated time, the Learning Dens activities became a useful model for practice to help young people open up about their experiences in a way that felt comfortable while virtual, while still engaging in collaboration and vulnerability.

Of course, the Learning Dens activity series is only one case study, and certainly cannot be considered representative of an entirely optimistic future for bringing this current generation of hypermedia knowledge organization tools into classrooms. It is worth acknowledging that having a team of researchers and designers to work on this project with the classroom, admittedly small as the team was, is more like the "hothouse" conditions that Justin Reich describes of the wiki-based tools in classrooms and cannot necessarily speak to the broad applicability of the tool in different conditions. Furthermore, the activity series was designed with the particularities of the COVID pandemic in mind and was set against the backdrop of incredibly unique conditions where educators were eager to find solutions to the sudden challenges presented by the pandemic and online learning. However, there are some broad lessons to be drawn from this experience which speak to the applicability of designing activities using the current generation of hypermedia knowledge organization tools in classrooms.

Lesson 1: Digital Cultures Continue to Shift

The first lesson from this experience is that the learners that we worked with in this initial project became quite comfortable with these types of tools and were able to pick them up *incredibly* quickly. While this tiny sample is certainly cannot be taken as fully representative, as we were working only with one class with an educator who was willing and interested in engaging with this type of work, the young students nonetheless were able to understand the ideas behind using a networked knowledge organization tool within one class session and were quickly experimenting and exploring. This comfortability is in stark contrast to many of the experiences described in the previous chapters, both in terms of students and educators taking significant time to learn how to effectively use the tools themselves. This demonstrated comfortability can be attributed to a combination of the fact that the tools themselves become

more intuitive and well-designed and that younger people have an increased comfortability and intuition when using networked platforms. Furthermore, especially after months of emergency remote learning, the students had already become comfortable conducting aspects of their school life in shared digital spaces like Google Classroom and Google Docs.

Lesson 2: Benefits of the "Series" Format with Networked Learning

Using the "activity series" format avoided the frictions mentioned in the wiki chapter about procrastination and rushing as an inhibitor of collaboration. When learners regularly returned to these spaces and were expected to make connections between what they are working and what their peers were working on, and between current and past work, it was much easier than expecting the same types of behaviors on one single finished product. Furthermore, having specified activities helped contain the boundaries of the extent to which students were experimenting with the platform during the classroom session; having a discrete goal to accomplish within a class session gave students enough scaffold to focus, while still exploring with Roam's features. The activity series format also offered the affordance of introducing specific features of the software to students over time, rather than expecting them to learn all the ins and outs of Roam Research before being able to begin with the activity series.

Lesson 3: Benefits of "Informal" Digital Gardening Contexts

Finding opportunities to employ hypermedia learning tools in "informal" learning spaces like the social-emotional learning block proved to be beneficial testing grounds for this type of activity series and applications of hypermedia learning tools generally. This is at least in part because these spaces avoid the frictions involved in needing to formally assess individual students. It was also a context slightly outside of planned normal "class" time. In this sense, even

at the beginning, students entered the Learning Den sessions with an attitude of being ready to experiment with something slightly different, and where there was room to play around. Furthermore, in this relatively low-stakes model, there was room for the educator to get comfortable learning with the platform as well. Throughout the Learning Dens activity series, the 7th grade educator followed along with many of the activities, even contributing her own personal milestones to the collective timeline. As a full group working together on building this shared garden space over the course of several months, the Learning Den environment became a reflection of the entire classroom's experiences of the pandemic, and a representation of their small community while learning remotely.

Conclusion: The Network and the Classroom

The network remains a central conceptual metaphor throughout each of these eras and technologies. As a theory of mind, the network was used to describe the nature of thought, learning and knowledge integration from the mid-twentieth century onward, from Bartlett's use of schemata in the 1930s to social constructivist models of learning. As a computational metaphor, the network was used to inspire and develop the interface designs and user interactions across hypermedia tools, from Ted Nelson's early diagrams through to the design of the wiki and to the interfaces of contemporary tools like Roam Research and Are.na. The network also has been used to describe aspects of social learning and large-scale group collaboration and societal change – from the massive-scale collaborative efforts of Wikipedia and other platforms, to Castells' model of the "network society." As a framework that bleeds across such a wide variety of disciplines and concepts, the notion of the network has acted as a tool to translate between these various theories of mind, computation, society, and learning. Unsurprisingly, new types of cross-disciplinary uses of the network metaphor continue to emerge today; artificial *neural* networks are network-based computational systems based on the biological understanding of a networked human brain.

Moments when hypermedia knowledge organization tools enter the classroom are particularly salient points at which many of these uses of the network metaphor collapse into the same space. In classroom uses of hypermedia knowledge organization tools, one can find a blending between various configurations of network-oriented models of cognition and learning,

digital network-based interfaces and interactions, and collaborative social networks of learners

working together in shared spaces. Writing about the reasoning for developing the M/Cyclopedia

project in 2005, for example, Bruns and Humphreys offer an example of how these variations of

the network metaphor meet in the classroom setting that is emblematic of these overlapping

usages:

> There are interconnections and synergies between the broad context of the new
> economy and its network structures...and the move toward social constructivist
> pedagogical models in education which employ social and collaborative project-based
> strategies for teaching and learning. New media tools such as blogs and wikis can help to
> implement networked, collaborative pedagogical strategies that help in teaching the
> literacies and skills students will need in a work environment in a knowledge based
> economy.[82]

Even in this brief quote, Bruns and Humphreys rapidly shift between these variations of the

network metaphor, from the economic and social scale described by Castells, to pedagogical

models of collaborative networks of learners, to specific network-oriented new media platforms

and technologies.

When looking across this history of hypermedia knowledge organization tools as the

converging of multiple models of network in classroom contexts, there are three broad ways that

one might read their series of successes and failures. There is, of course, the pessimist's view

that these tools and practices are fundamentally incompatible with traditional classroom

education as it currently stands, and that regardless of how much the tools mature, how

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[82] Axel Bruns and Sal Humphreys, "Wikis in Teaching and Assessment: The *M/Cyclopedia* Project," in *Proceedings of the 2005 International Symposium on Wikis*, WikiSym '05 (New York, NY, USA: Association for Computing Machinery, 2005), 25–32, https://doi.org/10.1145/1104973.1104976, 25.

comfortable students become with working with them, or even how much teachers' opinions change, this model of shared knowledge creation as learning will never become the norm in classrooms. When describing working with wikis and other Web 2.0 technologies, Nina Bonderup Dohn argues that the challenges of bringing Web 2.0 practices into educational contexts are "the result of conceptual tensions in the views of knowledge, learning, and the goals of the practice implicit in Web 2.0 practices on the one hand, and the educational system on the other."[83] Many of these sentiments have been repeated throughout the development and experimentation of hypermedia tools for learning, describing a "comprehensive rejection of teaching based on discovery, exploration and individual experience – the cornerstone of the hypermedia revolution in education which we are told to expect in the near future."[84]

The opposite perspective is that the tools and practices themselves simply have not matured enough, and once a fully effective hypermedia knowledge organization tool is designed, these types of tools will quickly become the norm. This is representative of the kind of "charismatic" and techno-optimistic stance discussed at the outset, that imagines changes to the tools themselves being the solution to any problems with lack of fit in classrooms. Describing the state of hypermedia in education in 1993, Nunes and Fowell attributed the failure of educational hypermedia to an attitude which "focuses undue attention on questions about what microcomputers and authoring packages can be made to do, thus distracting researchers, instructional designers and educators from asking more crucial questions about what this

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[83] Nina Bonderup Dohn, "Web 2.0: Inherent Tensions and Evident Challenges for Education," *International Journal of Computer-Supported Collaborative Learning* 4, no. 3 (2009): 343–63, 344.

[84] Gabriel Jacobs, "Hypermedia and Discovery-Based Learning: A Historical Perspective," *British Journal of Educational Technology* 23, no. 2 (May 1992): 113–21, https://doi.org/10.1111/j.1467-8535.1992.tb00317.x, 113.

technology should accomplish and what should be its role in the teaching and learning processes."[85]

However, when looking across these periods of hypermedia knowledge organization platforms and when considering the designs and a few examples of potential applications, the tinkerer's perspective sits somewhere in the middle. There are a few lessons from this middle-ground tinkerer's perspective that are important to conclude with. While widespread adoption of hypermedia knowledge organization tools and the pedagogical practices which often accompany them are unlikely to offer any wholesale transformations of the educational system broadly in any short term, one can begin to consider and design for meaningfully incremental changes in this space, where the considerations of the *fit* of the how the tools are used are as important as the design of the tool itself. When comparing the hypermedia knowledge organization tools from the current moment to the past examples, the increasing accessibility of these types of tools from a setup standpoint has only grown easier as time passed. Even though it was using one specific case and cannot be considered representative of young learners broadly, the ease with which the 7th grade students were able to understand and quickly begin using Roam Research for their Learning Den activities was incredibly encouraging, as was the teachers' willingness and ability to quickly learn and begin experimenting with the tool as well. As these types of tools become more of a norm as notetaking and knowledge organization tools *outside* of classrooms for learners, finding new ways of bringing them in will likely only become easier as well. Both cultural and technological shifts are likely not enough to induce any large-scale transformation, but the continued development of these types of tools and further experimentation of specific

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[85] José Miguel Baptista Nunes and Susan P. Fowell, "Hypermedia as an Experiential Learning Tool: A Theoretical Model" (Professor T.D. Wilson), accessed March 17, 2021, http://informationr.net/ir/2-1/paper12.html.

moments in which they might fit in classrooms will likely expose more educators to these types of tools and offer new contexts for experimentation.

Despite its pervasiveness, perhaps the associative network of shared knowledge is merely a passing model. While the network metaphor found its zeitgeist in the early hypermedia diagrams in the 1960s which carried through the twentieth century and into these first decades of the twenty-first, it would not be the technology and conceptual metaphor to translate across media forms and theories of knowledge.

We might briefly take photography as an example of this kind of passing popularity of a growing media form used as a cognitive and pedagogical metaphor. With the emergence and popularization of photography into the early 20th century, one can trace many of the same types of cross-disciplinary methods involving using a new media form as both a metaphor and real tool to imagine new types of learning and classrooms and formulate theories of mind. As the camera and photography were becoming more widespread, photographic metaphors were at once used to describe physiological retention of visual memories. As early as 1874, an American scientist and philosopher named John William Draper described all sensory impressions as leaving a "permanent trace" like a photographic image. From Draper's early descriptions and into the 20th century, the metaphor of the photograph as a kind of immutable memory was used to describe how the human mind retained experiences and ideas.[86] And just as the photograph was used as a metaphor to describe aspects of memory and the brain, photographs were being used in educational contexts to propose deeper models of learning. In 1913, Thomas Edison, one of the pioneers for developing machines to display static and motion pictures, was confident that they

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[86] Douwe Draaisma, *Metaphors of Memory: A History of Ideas about the Mind* (Cambridge University Press, 2000), 121.

would become so ubiquitous as to overtake books entirely, suggesting that "books will soon be obsolete in the public schools. Scholars will be instructed through the eye."[87]

When it comes to learning and organizing knowledge with technology, the network model may drift towards new metaphors to describe how learning does, or should, occur, just as photographic metaphors for cognition and learning drifted out of frame. Indeed, the garden metaphors used to describe and define digital knowledge networks may be a potential growing space for considering new types of digital systems for sharing and building knowledge that could sit parallel to, or outside of, the network metaphor. Even as new pedagogical practices continue to develop alongside this new generation of tools continued to open the design space for considering how to learn with networks, it may be a useful practice to already begin recognizing such alternative metaphors as they emerge. Just as the network models for understanding thinking, learning, and collaborative knowledge building emphasize connection-making and interconnection, the garden metaphor carries notions of a recognition of time, manageable scales, careful tending to knowledge. When taking the tinkerer's perspective by carefully considering how well technologies might fit into classrooms, perhaps tools, pedagogies, and models of learning which build upon ecological metaphors like the garden, or the "networked garden," may find deeper fit in future classrooms, and in our changing world.

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[87] Anuli Akanegbu, "Vision of Learning: A History of Classroom Projectors," Technology Solutions That Drive Education, 2013, https://edtechmagazine.com/k12/article/2013/02/vision-learning-history-classroom-projectors.

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