From the Mainframes to the Masses: A Participatory Computing Movement in Minnesota Education

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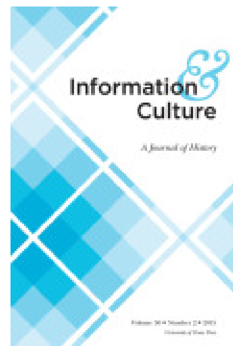

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Historians have demonstrated how systems like Usenet and Minitel fostered the social practices that we now associate with the TCP/IP Internet, but no one has considered networked computing in education. From 1965 to 1975, Minnesota implemented interactive computing at its public schools and universities with time-sharing systems—networks of teletypewriter terminals connected to computers via telephone lines. These educational networks, created with different priorities from military-sponsored networks, were user oriented from the start and encouraged software sharing and collaboration. Focusing on the educational setting gives us a history of the Internet firmly grounded in the social and political movements of the long 1960s.

During the spring of 1971, teacher Thomas Duff reported that his students exhibited a roller coaster of emotions as they played a computer game. Duff taught business in Richfield High School, in a suburb just south of Minneapolis, Minnesota, and his students eagerly immersed themselves in a computer simulation called MANAG, whereby the students competed against each other to best manage a company. These students, many of whom had been written off as "low-ability," "anxiously watched the print out for their team and alternately cheered and moaned as they received the results. Some students who had not been involved in class activity to this time became deeply involved in making decisions and registered emotion for the first time as they watched the results of their team's decision being printed on the teletype." Duff delineated how computing became personal for these students. They invested emotion

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in their computer experiences; some even "develop[ed] a certain pride" from their practice.[1] And the students exhibited a mode of personal computing now quite familiar: waiting eagerly for text-based output.

The Richfield School System belonged to a unique organization known as Total Information for Educational Systems, or TIES. In 1967 eighteen Minnesota school districts formed TIES as a cooperative venture to provide educational and administrative computing to their students and teachers.[2] The TIES districts had been inspired by a 1965–66 computing experiment at nearby University High School (UHigh) in Minneapolis. The success of TIES propelled the creation of the Minnesota Educational Computing Consortium (MECC) in 1973.[3] During 1974–75, MECC's statewide time-sharing system served 84 percent of Minnesota's public school students.[4] Analyzing the growth of TIES and MECC illuminates the social and technical practices of networked computing that were distinctive to the networks' origins within education during the 1960s. The individuals who established TIES and MECC focused on schoolchildren and their teachers as users and innovators. The networks' employees, teachers, and students emphasized access, cooperation, and emotional and intellectual engagement. They cultivated a community around their time-sharing networks, built around a social vision of collaboration and user orientation. For TIES and MECC users, computing became both participatory and personal.

Highlighting the educational origins of TIES and MECC underscores the diversity of networks and social practices that have created our contemporary pervasive computing culture but that we now associate exclusively with the TCP/IP Internet. The ubiquity of today's Internet has led to a proliferation of academic and popular Internet histories.[5] Many people are now familiar with the Internet's origins as a military project funded by the United States Department of Defense Advanced Research Projects Agency (ARPA), ARPANET.[6] Yet, as several scholars have highlighted, the attention to the history of ARPANET-becomes-Internet obscures the extensive history of other computer networks from the 1950s onward.[7] Other scholars have begun to chronicle the multifarious origins of the technical, social, and political practices that we now identify only with the TCP/IP Internet.[8]

This article contends that TIES and MECC users engaged in social and creative computing practices that now feature prominently in today's Internet user experience, including networked gaming, social networking sites, and user-generated content. In doing so, this article enriches the growing body of scholarship that examines the history of computing and networking as experienced by the user.[9] The historian of technology Steven Lubar cogently declares, “We have downplayed the skill and knowledge required by users of technology, looking at the machine and not the task, looking for complex systems on the production side, not on the consumption side.”[10] Many existing computing and networking histories focus on computing professionals and their technical achievements, but amateur users have always shaped computing systems in important ways. This article also draws attention to the important but little-studied area of the history of computing in education. Historians have not yet addressed the “skill and knowledge required by users” of computing in schools. An exploration of the history of computing in an educational context is particularly promising. In the case of interactive computing, students and educators were some of the earliest groups of users, and they developed “complex systems” around time-sharing. We must attend to the history of computing and networking from the ground up—from the user’s perspective—in order to fully grasp the evolution of our contemporary computing culture.[11]

The movement for participatory computing in Minnesota, embodied by TIES and MECC, was firmly grounded in the social and political movements of the long 1960s. Indeed, education was both a key site and a method of the civil rights movement, the student movement, the women’s movement, and the environmental movement. Historians including Glenda Gilmore, Barbara Ransby, and Katherine Charron have demonstrated the significance of educators and schools to the civil rights movement, and Adam Rome has emphasized that the first Earth Day of 1970 was, in fact, a “teach-in” that extended across the United States over several days.[12] The educators who organized TIES and then MECC sought a participatory political culture for their computing networks. In fact, the growth of social computing in Minnesota paralleled the organizational activities of numerous other rights and protest movements, as this article will document. Here, a focus on education gives us a history of Internet use that is situated within the social and political upheaval of the 1960s, a sharp contrast to those existing narratives focused on military and defense origins.

The focus on Minnesota is neither provincial nor coincidental. From the 1950s through the 1980s, Minnesota enjoyed a thriving economy based on computers.[13] At the time, no other region in the United States could match Minneapolis–St. Paul for the concentration, size, and success of its computer industry. This regional business grew from the pioneering Engineering Research Associates, founded in 1946 and an early manufacturer of state-of-the-art computers. The Minnesota economy was anchored by the presence of major corporations Control Data, Honeywell, Sperry-Rand Univac, and IBM—Rochester, but hundreds of other companies large and small supplied necessary parts, services, and know-how for the large computer companies. The Minnesota computer industry profoundly affected the culture of the state, especially in the Twin Cities area. Residents had a "computer identity," viewing themselves as at the forefront of technology.[14] During the 1960s and 1970s, Minnesotans excelled at computing, from the boardroom to the classroom. This leadership extended beyond TIES and MECC. During the 1960s and 1970s, Minnesota-based Control Data substantially contributed to the development of the interactive PLATO system at the University of Illinois at Urbana-Champaign, another time-sharing system on which thousands of users created individualized, interactive computing.[15]

TIES and MECC built their networks around time-sharing; the technological form of time-sharing and the social organization of these networks went hand in hand. Time-sharing was a type of computing in which multiple users simultaneously shared the resources of a powerful central computer, whether it was a larger mainframe or a smaller minicomputer.[16] The individual user typically ran her programs and received results via teletypewriter (or teletype) terminals, connected to the computer via telephone lines. The teletypewriters resembled oversized QWERTY typewriters. With time-sharing, a user could type commands into the teletype and receive printed responses on that teletype within seconds. Moreover, because of the connection via telephone lines, the teletype could be located in a different city or even a different state from the central computer.

The level of interactivity and computing over a distance enabled by time-sharing was a dramatic change from the dominant mode of computing, using mainframe computers. Indeed, the 1960s are typically remembered by historians of technology as the decade of the mainframe.[17] Mainframe computers typically were programmed using punched cards. Each cardboard card measured about three inches tall and eight inches wide, and holes "punched" or cut out of the card at a particular location directed the computer to execute a corresponding command or receive numbers or letters as input. A person programmed the computer by creating a stack of punched cards in a particular order; the stack was then handed over to the mainframe operator for input and processing. The programmer received his results via a printout that he retrieved from the mainframe operator, often hours or even days later. In contrast, a student sitting at a TIES teletype received his results at that teletype within minutes.

For TIES and MECC users, personal computing and networked computing were inseparable. The students and educators of TIES and MECC embraced time-shared computing for entertainment and personal information processing. They created programs to compose music and to process their income taxes; they savored simulations such as MANAG, the business game, and SUMER, in which they ruled an ancient civilization. They shared their programs, as well as their burgeoning computing expertise, through the TIES and MECC networks. TIES and MECC users made computing their own—they made it personal—in many ways: they had one-on-one interaction with the teletypes; they computed for productivity, for communication, and for fun; they experienced emotional engagement and sociability with their computing; and they cultivated computing communities.

This article documents the movement for participatory computing in Minnesota by first tracing its origins in a computing experiment conducted at UHigh in Minneapolis starting in 1965. Several UHigh teachers then employed social movement organizing tactics to call for more computing in the classroom. The resulting network, TIES, employed an intensive communication strategy to encourage participatory computing. The TIES network's success with user-generated content and a software library propelled the statewide network, MECC. MECC replicated the communications strategies of TIES and, more importantly, developed a statewide telecommunications network to support widespread interactive, individualized computing.

University High School: The Experiment

Dale LaFrenz has characterized himself as a math teacher rather than a mathematician, but he is, at heart, a salesman.[18] Throughout his career, he has sold the idea of computing in the classroom to peers, administrators, and students in Minnesota and across the United States—starting at one high school. LaFrenz was one of four new teachers in the mathematics department at UHigh in Minneapolis for the 1963–64 school year.[19] The College of Education at the University of Minnesota had established UHigh in 1908 as a place to conduct research on teaching and learning, to train teachers, and to experiment with novel curricular approaches emerging from the college.[20] UHigh was, in short, a laboratory school, and both its teachers and its students were guinea pigs. UHigh prided itself on being at the forefront of innovation, and during that 1963–64 school year, the new math teachers searched for a novel educational experiment for themselves and their students.

Inspired by Minnesota's thriving computing economy, LaFrenz and his colleagues aimed to "bring the computer into the classroom."[21] They were curious about whether the computer could be used effectively in an educational setting, and they soon learned of a promising way to study this: the Dartmouth Time-Sharing System. The mathematics professors John Kemeny and Thomas Kurtz, along with a team of student programmers at Dartmouth College in Hanover, New Hampshire, had successfully implemented a time-sharing system using General Electric (GE) computers in May 1964.[22] Kemeny agreed that the UHigh teachers and their students could join the Dartmouth Time-Sharing System, provided that UHigh cover the high cost of long-distance telephone service from Minnesota to New Hampshire.[23]

The Dartmouth system appealed to the math teachers at UHigh because they could install a teletype at the school, thereby providing their students with hands-on access. LaFrenz and his colleagues considered student use of the teletype (not the mainframe computer itself) a form of computing. LaFrenz emphasized, "We put the teletypewriter in the classroom. That's really where the whole computer in the classroom started."[24] Moreover, the teachers presented teletype usage to their students as computer usage. For 1965–66, the first year of the experiment, UHigh sought and received $5,000 of funding from the GE Foundation because GE had provided the computer for Dartmouth. Most of that grant was applied to long-distance service from Minneapolis to Hanover.[25]

The experiment included seventh-grade classes taught by Larry Hatfield, ninth-grade classes taught by Dale LaFrenz, and eleventh-grade classes taught by Thomas Kieren.[26] LaFrenz's students employed the computer in learning about the order of mathematical operations and the evaluation of numerical expressions.[27] Hatfield's seventh graders in the experimental group used the computer to learn about exponential numerals, while Kieren's eleventh graders studied linear and quadratic functions with the computer.[28] The teachers were united in their conviction that the "computer could serve to provide problem-solving experiences for all students in grades 7–12," not just those who were mathematically talented or those in grades 11 and 12.[29] After two years, the UHigh instructors deemed their experiment a success.[30]

From UHigh to TIES: The Network Grows

LaFrenz and his fellow UHigh teachers eagerly spread the word about computing in the classroom, especially after time-sharing costs dropped dramatically. In 1965 the Minneapolis-based Pillsbury Company became the first commercial venture in the nation to purchase a GE-635 computer, and Pillsbury soon opted to install and sell time-sharing on its GE machine.[31] UHigh switched its teletype connection from Dartmouth to the Pillsbury subsidiary Renown Properties in February 1966.[32] The UHigh group recognized that this local time-sharing option eliminated the long-distance costs associated with their computing model, and they aspired to expand the student computing experience. The partnership between UHigh and Pillsbury underscored another dimension about time-sharing networks, namely, that their reliance on telephone service made for local or regional networks.

LaFrenz reminisced, “The five of us began evangelizing the use of the computer in the classroom and what we were doing and time-sharing. We began going to the Minnesota Council of Teachers of Mathematics meetings to ‘sell’ our idea. Pretty soon there was quite a cadre of people in the Twin City area who had convinced schools to buy teletypes and hook up and start using the computer in the classroom.”[33] Indeed, the council provided the UHigh group with a ready-made and receptive network through which they could propagate their idea. During 1965–66, David Johnson served as coeditor for the council newsletter, providing the crucial connection between the UHigh experimental group and a large statewide network of educators.[34] As editor, he arranged for two council articles publicizing the UHigh computing situation. Johnson sought to convince others to join the computing crusade. In his own piece, he concluded, “In view of the tremendous impact of computers on our society it is with great excitement and expectation that the department is conducting this research.”[35] Johnson tapped Larry Hatfield to publish in the May 1966 issue of the council newsletter, and Hatfield also advertised the UHigh experiment.[36] Johnson soon promoted computers in the classroom to a national audience at the 1967 conference of the National Council of Teachers of Mathematics.[37]

LaFrenz’s, Johnson’s, and Hatfield’s efforts to convince other schools about the importance of computing in the classroom paralleled the tactics of their 1960s social movement contemporaries. The political scientist and activist Jo Freeman has argued that a social movement required (1) a preexisting communications network that was (2) readily co-optable, as well as (3) additional organizing work to disseminate the new idea.[38] Applying that analysis to Minnesota computing highlights the methods by which LaFrenz and his colleagues laid the groundwork for a participatory TIES network. They promoted their idea through the preexisting communications network of the council. They deployed both the newsletter and meetings to recruit other educators to the cause of instructional computing. The additional organizing work would come through the development and growth of TIES. The individuals associated with TIES exhibited the characteristics of a social movement: they were conscious of a shared enthusiasm for computing; they demonstrated a missionary impulse to spread their message; and they mobilized many others to pursue a common cause, culminating in MECC.

By January 13, 1967, eighteen school districts in the Twin Cities region had adopted resolutions to join the Minnesota School Districts Data Processing Joint Board, which became known as TIES.[39] Minnesota law enabled the school systems to form a cooperative venture to pay for—and share—the resources of a large mainframe computer to provide both administrative and instructional computing for over 130,000 students.[40] This was an expense and undertaking that almost no single school district could afford on its own.[41]

The TIES schools sought federal government support for their project under the Elementary and Secondary Education Act of 1965 Title III, and the funding application evidenced three critical features of this particularly Minnesotan project.[42] First, teachers were considered partners in the development of the technological system and were consulted from the outset. Second, the area was permeated by its own high technology culture surrounding the numerous local computing companies. Finally, the university also acted as a key contributor, as it had for University High School. Indeed, TIES manifested the same constellation of forces as UHigh: teacher expertise and innovation, bolstered by the university, and situated within a high-tech hub.

The school districts of TIES planned to financially support their computing endeavor themselves after they had used the Title III funding, and this plan for self-sustainability required growth to include additional school districts.[43] The system planned to operate on per-pupil membership fees from participating districts. As more school districts joined TIES, the number of students served increased, and the fixed costs associated with owning and operating the time-sharing system decreased by being spread among more districts. To stimulate growth, the employees and supporters of TIES adopted the organizing techniques of the movements of the 1960s to spread their message around the Twin Cities and across Minnesota. They worked to persuade existing school districts of the value and utility of their investment in computing, and they strived to persuade other school districts to join in their computing collaboration. To maintain existing members and recruit new ones, TIES staff organized their activities to instill a sense of accomplishment and pride for TIES efforts and to meet the computing demands of their large constituency. TIES used three key techniques to accomplish these goals: meetings, local coordinators, and newsletters.

The TIES technological network was simultaneously a social network, and the social network was grounded in the participatory politics of the 1960s. The TIES staff organized numerous school visits, meetings, and training sessions to inform and energize their constituents about the potential of their information system. These face-to-face encounters comprised a TIES effort at mobilization. The meetings commenced shortly after TIES began operations; each of the twenty-one member school districts received a visit from joint board personnel between Thanksgiving and Christmas 1967.[44] These meetings among TIES staff and member teachers, administrators, and students continued on a frequent basis over the next five years; this frequency highlighted their value to the TIES organization.[45] In fact, the layers and diversity of groups organized are striking. The June 1968 issue of the *TIES & TALES* newsletter detailed a meeting of the joint board, with members drawn from each school district, as well as workshops for the Educational Information System coordinators from each district, a Technical Committee meeting, and a computer concepts seminar attended by representatives from all member districts.[46]

A key aspect of TIES's success was this attention to individuals, the in-person component of its growth strategy. Part of the TIES mission was to familiarize teachers and administrators with computing and everything it could do for them. TIES Executive Director Thomas Campbell, Assistant Director Jerome Foecke, and the others recognized that the people in their system were just as important as the machines. The movement's leaders encouraged frequent person-to-person contact to ensure that questions were answered, concerns were allayed, insights were shared, and milestones were celebrated.

Closely related to this communications strategy of frequent meetings was the TIES requirement that each member district designate an Educational Information System coordinator, who liaised between the district and TIES. One of the coordinators, Irv Bergsagel, reported that he essentially served as a "communications link."[47] Bergsagel realized that he and the other coordinators played a vital role in the TIES network. They kept information and ideas moving within their time-sharing computer network and their computing community. The coordinators embodied all of the local places within the TIES community, as well as the spaces in between and imagined on the computer network.

TIES launched its *TIES & TALES* newsletter in September 1967 to apprise members of its activities.[48] It published the newsletter several times during the academic year and distributed a total of eighteen *TIES &*

TALES newsletters during the first five years of operation.[49] The initial TIES staff carefully attended to the geography of member schools in the TIES newsletter articles, thereby creating a network across member districts and beyond for their readers. The emphasis on place extended beyond Minnesota. As reported in the newsletter, TIES staff communicated with colleagues in New York, New England, California, Michigan, and Oregon.[50] They welcomed visitors from Michigan, Palo Alto, and the University of Southern California.[51] They reported on an educational technology conference in Scotland and on student computer simulations in Westchester County.[52] TIES staff used their newsletters to create a network of individuals, schools, and school systems across Minnesota linked by time-sharing, but they also forged connections and a sense of belonging in a network across the United States and beyond. The TIES staff filled each newsletter with the promise of computing.

The software banking and other network effects that TIES facilitated underscore the importance of understanding TIES as people focused and community based, that is, as a social network. The use of time-sharing in TIES member schools exploded during 1970, paralleled by the emergence of TIES as a software repository. During the 1970–71 school year, over 26,000 students used the TIES teletypes.[53] The newsletter explained, "As more and more teachers and students become involved with the BASIC [programming] language and the use of the computer, additional programs are generated and additional uses of the devices are developed."[54] The special structure of TIES enabled this phenomenal growth of usage and programs: if one student in one member district wrote a program, she could save it to the TIES computer library, where it could be called up, used, and modified by another student or teacher in another TIES member district.

TIES students and educators interacted with their terminals in myriad ways. Students eagerly played games such as CIVIL (a Civil War simulator) and MANAG, even outside of class.[55] Older students created entertaining and informative demonstrations about computing for younger students. Another group of students recorded a video about how information was processed from the teletype to the computer, and Linda Borry, a teacher, programmed the computer to compose music.[56]

This rapid growth prompted TIES to create a new role in each member district, that of the terminal supervisor. The terminal supervisor supported the use of the computer in the classroom and encouraged use of the software library.[57] With the terminal supervisor, TIES effectively instituted a "Help Desk" role in each member school system in 1970. The development of this role evidenced TIES's status as a software creator and the staff's awareness of the importance of supporting users. The TIES staff recognized that maintaining and energizing their existing user base was just as critical as recruiting new member districts.

In fact, the terminal supervisor role was one piece in the complex system that TIES administrators and educators developed to regulate use and access around the increasingly popular time-sharing system. One middle school teacher "established a procedure for students to receive a computer operator's license similar to a driver's license," and other schools followed suit.[58] By October 1972, there was enough competition for teletype time that winning a personal user ID with unlimited access time for one month was a valuable prize.[59]

A final emblem of the expanding enthusiasm for instructional computing was the launch of the *Timely TIES Topics* newsletter in September 1972.[60] The newsletter was devoted to sharing student computing news and programming ideas, and it demonstrated that computing in the classroom was becoming institutionalized. The teletypes were integrated into the classroom spaces of TIES member schools, and teletype usage was embedded as an option for thousands of students. Because *Timely TIES Topics* regularly included contributions from TIES teachers and students, and because those contributions always included school location information, the newsletters together with the time-sharing system represented a distributed yet connected network. Readers belonged to a community that was connected by telephone lines and computers and by the possibilities and passions of computing.

A Statewide Network: MECC

By the early 1970s, TIES was not the only organization offering interactive computing experiences to students and educators in Minnesota. Several similar projects had been successfully installed, and this proliferation of computing attracted the attention of Minnesota governor Wendell Anderson. TIES had achieved its goal of becoming a model for others. The Minneapolis Public Schools arranged for their own time-sharing computer, with a terminal in every school.[61] A cooperative of private colleges, public community colleges, and public state universities formed the Minnesota Educational Regional Interactive Time-Sharing System (MERITSS) in 1971. This extensive time-sharing network originated from a computer housed and managed at the University of Minnesota in Minneapolis.[62] Similarly, Mankato State College hosted a time-sharing network for southern Minnesota known as the Southern Minnesota School Computer Project.[63]

Thousands of people were computing. These were not just students doing preprogrammed drill exercises or even programming for their math assignments. Students were figuring out how to score volleyball games and swim meets, and they were learning history—or relaxing in their spare time—by playing simulation games such as CIVIL, in which the player chose Civil War battle strategies and soldier conditions.[64] High school athletic coaches were scheduling tournaments, calculating player statistics, and even determining their scouting choices via teletype terminals on time-sharing systems.[65] The numerous computing ventures called attention to the costs and inequalities of educational computing in Minnesota, and in July 1972 the Governor's Joint Committee on Computers in Education convened to review the state's computing activities, ultimately resulting in the establishment of the Minnesota Educational Computing Consortium, or MECC.[66]

MECC proposed to unite the computing needs of the K–12 schools, the community colleges, and the state universities under one organization, and, as a result, members of those different communities questioned MECC from the outset. Moreover, MECC was essentially a product of the state, and the government involvement also invited criticism. Whereas TIES, MERITSS, and the Southern Minnesota School Computer Project had developed locally, from the ground up, MECC originated as a top-down government mandate.

Revising the proposed MECC agreement to include strong language for users' rights quelled the concerns of both the university and the K–12 school districts, including the TIES districts. The addendum, the last four pages of the agreement, presented the "MECC Basic Principles of Organization and Operation."[67] The governor's committee included these "fundamental" principles to address concerns about state control and about the balance of decision-making power; many of the principles centered on the "user," which the committee defined as "the systems and institutions of education which use services of the proposed consortium."[68] These principles proclaimed a bill of rights for the users, mandating that "the governance of the consortium will be under the control of the users," and "the needs for services will be defined by the users."[69] The MECC agreement was signed by the four Minnesota educational agencies, and MECC officially commenced operations on July 1, 1973.[70] Minnesota's educational institutions endorsed MECC because its constitution embraced users' rights.

During its inaugural 1973–74 year, MECC drew heavily from Minnesota's existing abundance of computing resources, including human resources, and the MECC staff implemented the techniques of meetings, newsletters, and coordinators that had contributed to TIES's success. Indeed, the early years of MECC attested to the entrenchment of interactive computing in Minnesota. The first three MECC assistant directors —Dale LaFrenz, Dan Klassen, and John Haugo—had been associated with TIES.[71] LaFrenz and his colleagues organized numerous TIES-like training sessions for teachers throughout Minnesota. By July 1974 MECC had introduced nearly four hundred teachers to the possibilities of interactive computing.[72] In addition to using the TIES technique of meetings as part of its technological system, MECC also deployed local and regional coordinators and newsletters.[73]

MECC's primary focus during that 1973–74 school year was the extension of time-sharing services to the outstate regions of Minnesota. It built on the computing knowledge and infrastructure developed in Minnesota over the past decade. The time-sharing systems MECC used encompassed TIES, MERITSS, the Minneapolis Public Schools, Mankato State College, Bemidji State College, and St. John's University.[74] Over the course of the 1974–75 school year, MECC's statewide time-sharing system utilized five Hewlett-Packard 2000 minicomputers, one Univac 1106 mainframe computer, and one Control Data Corporation 5400 mainframe computer.[75] Together, these computers provided about 450 ports, or telecommunications entry points to the computers, accessed by approximately 800 terminals across the state.[76] However, making this plan, which involved numerous different systems, work was not simply a matter of installing teletype terminals in school districts located in remote regions of the state.

MECC's achievement in creating a statewide instructional time-sharing system entailed the development of a statewide telecommunications network dedicated to supporting this initiative. Individuals using teletypes to interact with time-sharing computers moved their data over telephone lines, and the cost of telephone time for calls beyond a limited local area was expensive. For example, Hibbing, Minnesota, one of MECC's school districts located about two hundred miles north of Minneapolis, was also about one hundred miles east of the nearest time-sharing computer at Bemidji State College. The MECC staff worked with the telephone companies of Minnesota to develop cost-effective means of connecting districts like Hibbing with remote time-sharing computers. One component of MECC's solution was the use of multiplexors, which were "communications devices that concentrate[d] many calls across one line to the computer."[77] In October 1974, when the network was 90 percent complete, MECC had established thirteen multiplexors around the state to reduce telecommunications charges.[78] Furthermore, the MECC staff worked with the telephone companies to install toll-free lines (at the time, telephone lines accessed by dialing an area code of "800") for "very remote schools."[79] Thus, the MECC staff, with the cooperation of the Minnesota telephone companies, adapted existing technologies for new purposes to implement their statewide time-sharing system. In this case, the statewide computer consortium acted for multiple districts across the state and therefore merited far more attention from telephone companies (and other businesses) than a single school district would.

In addition to exercising their purchasing power with the telephone companies, the MECC staff also worked with teletype businesses to extend instructional time-sharing beyond the Twin Cities metropolis. MECC negotiated a "cost beneficial arrangement" whereby MECC became the seller, or provider, of teletypes to school districts. Here, too, the consortium relied on bulk purchasing to benefit member school districts. Minnesota schools could purchase a popular teletype model at a discounted price.[80] MECC also promoted a statewide teletype maintenance agreement through Minnesota-based Tele-Terminals, Inc. This contract allowed school districts to receive maintenance and service calls for their teletypes—regardless of whether they were purchased through MECC—at a discounted rate.[81] Thus, MECC encouraged school districts throughout the state to put computers in their classrooms by reducing the actual cost of obtaining and servicing the requisite teletype and by minimizing the decision making associated with an individual school district purchasing its own teletype, finding a time-sharing provider, debating whether to enter a maintenance contract, and wondering how to actually use time-sharing.

MECC created a network of networks through innovative communications solutions, through business negotiation, and by building on the extensive foundation of existing Minnesota time-sharing. This network of networks enabled thousands of students and educators across Minnesota to program and personalize their computers. Prior to the 1974–75 school year, the Minneapolis–St. Paul metropolitan area accounted for the overwhelming majority of classroom computing in Minnesota school districts. Before MECC, only 14 percent of Minnesota students with access to instructional time-sharing were outside of the Twin Cities metropolitan area. Once MECC implemented a statewide time-sharing system in 1974–75, that number tripled to 46 percent.[82] During that first year of its statewide time-sharing system, MECC served 84 percent of the public school enrollment in Minnesota.

Conclusion: The Bug in BAGELS

During the winter of 1974, interactive computing thrived in schools in Minnesota. Students in TIES member schools played YAHTZE on their time-sharing terminals, a version of the classic dice game Yahtzee written at a TIES school by student teacher David Auguston.[83] Linda Borry, the teacher who programmed the TIES computer to play music, now worked on the TIES instructional staff, and she solicited help with an ongoing problem. Borry reported, "It has been brought to our attention that there is a bug in the BAGELS program which periodically causes it to print out incorrect clues. Can you help us find this bug?"[84] BAGELS was an elementary math logic game in which the computer provided clues about a mystery number and students guessed the number. Borry knew that her computing community would help resolve the problem. Similarly, Tom Mercier, a wrestling coach at TIES member Lakeville Junior High School, impressed his colleagues with his computer prowess. He programmed the TIES time-sharing computer to calculate all of the pairings for Lakeville's fifth annual invitational junior high wrestling tournament, involving 9 teams and 158 wrestlers. Mercier's program saved significant time during the meet and became part of the constantly growing TIES library as a resource for others.[85] Meanwhile, LaFrenz, who had started his journey at UHigh and worked with Linda Borry at TIES, diligently worked to build MECC's staff, create a telecommunications network crisscrossing the state, and share his zeal for computing with educators around Minnesota.

Focusing on the networks developed from UHigh through MECC reveals the spirit of collaboration that animated individuals like Borry and LaFrenz. Indeed, TIES cultivated people, not just hardware, as the crucial component of a vibrant information network. TIES employees and affiliates also organized their venture as a social movement, using newsletters, meetings, and local coordinators to mobilize Minnesota communities and to spread the gospel of computing. Moreover, LaFrenz, Borry, and their colleagues worked with—and pushed—the limits of 1960s and 1970s computing systems in an effort to connect those computers with many different people (not just tech-savvy individuals) as soon as possible. They did not dwell on the limitations of time-sharing; rather, they maximized computing opportunities. They built collaborative, user-focused, education-driven computing networks around their time-sharing systems. Sometimes the Minnesotans improved the technology, but they always prioritized increasing access. And in the process, these leaders and their many users redefined computing.

Hundreds of thousands of Minnesota students and educators made computing their own. For these TIES and MECC users, computers no longer loomed as a specter of science fiction, nor were they only the province of scientists and engineers. Large corporations, the US military, and research universities did not have a lock on regulating computer access. Instead, for the participatory Minnesotan computing community, computing became individualized and interactive. Computing became accessible and personally meaningful as a way to do homework, play games with friends, find a date, or calculate taxes owed.

Studying TIES and MECC demonstrates the importance of unconventional settings for the history of networks and the history of computing. It seems that education has been overlooked largely because we imagine that technological use in the classroom was narrowly circumscribed. This underestimates the creativity and agency of users in the field of public education in shaping technologies. Examining TIES and MECC also illustrates the value of looking beyond the technical implementation of a network, for TIES and MECC thrived based on their social practices and their time-sharing capabilities. Similarly, the history of TIES and MECC underscores the human labor required to produce networked computing. For networks, computing, and networked computing, we must move beyond details of devices and protocols to consider the history of human actions and activities in creating applications, ascribing value, bridging infrastructure and access, and determining social practices. After all, the students and educators of TIES and MECC cultivated participatory computing, and their legacy informs networked computing today.

Notes

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1. *TIES & TALES* 4, no. 5 (June 1971): 6. This newsletter was issued by the Minnesota School Districts Data Processing Joint Board (widely known as TIES). All issues cited in this article can be found in box 1, collection 138, Charles Babbage Institute (CBI), Center for the History of Information Technology, University of Minnesota, Minneapolis.

2. *TIES & TALES* 1, no. 1 (September 15, 1967).

3. John E. Haugo, "Minnesota Educational Computing Consortium," April 1973, http://www.eric.ed.gov/ERICWebPortal/contentdelivery/servlet/ERICServlet?accno=ED087434.

4. Minnesota Educational Computing Consortium (hereafter MECC), *Systems Update* 2, no. 1 (January/February 1975): 3, microfilm, Minnesota Historical Society, St. Paul.

5. For example, Katie Hafner and Matthew Lyon, *Where Wizards Stay Up Late: The Origins of the Internet* (New York: Simon & Schuster, 1996); Tim Wu, *The Master Switch: The Rise and Fall of Information Empires* (New York: Alfred A. Knopf, 2010).

6. Arthur Norberg, Judy O'Neill, and Kathy Freeman, *Transforming Computer Technology: Information Processing for the Pentagon, 1962–1986* (Baltimore, MD: Johns Hopkins University Press, 1996); Janet Abbate, *Inventing the Internet* (Cambridge, MA: MIT Press, 1999).

7. Martin Campbell-Kelly and Daniel D. Garcia-Swartz, "The History of the Internet: The Missing Narratives," *SSRN eLibrary*, December 2, 2005, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=867087; Andrew L. Russell, "Histories of Networking vs. the History of the Internet," paper presented at the SIGCIS Workshop, Copenhagen, 2012, http://arussell.org/papers/russell-SIGCIS-2012.pdf.

8. Michael Hauben and Ronda Hauben, *Netizens: On the History and Impact of Usenet and the Internet* (Los Alamitos, CA: IEEE Computer Society Press, 1997); Christopher McDonald, "Building the Information Society: A History of Computing as a Mass Medium" (PhD diss., Princeton University, 2011); Ramesh Subramanian, "Murray Turoff: Father of Computer Conferencing," *IEEE Annals of the History of Computing* 34, no. 1 (2012): 92–98.

9. Atsushi Akera, "Voluntarism and the Fruits of Collaboration: The IBM User Group, Share," *Technology and Culture* 42, no. 4 (2001): 710–36; Nelly Oudshoorn and Trevor Pinch, eds., *How Users Matter: The Co-construction of Users and Technology* (Cambridge, MA: MIT Press, 2003); Nathan Ensmenger, *The Computer Boys Take Over: Computers, Programmers, and the Politics of Technical Expertise* (Cambridge, MA: MIT Press, 2010); William Aspray and Jeffrey Yost, "New Voices, New Topics," *IEEE Annals of the History of Computing* 33, no. 2 (2011): 4–8.

10. Steven Lubar, "Men/Women/Production/Consumption," in *His and Hers: Gender, Consumption, and Technology*, ed. Roger Horowitz and Arwen Mohun (Charlottesville: University Press of Virginia, 1998), 20.

11. Nathan Ensmenger, "Power to the People: Toward a Social History of Computing," *IEEE Annals of the History of Computing* 26, no. 1 (2004): 96–95; Joy Rankin, "Toward a History of Social Computing: Children, Classrooms, Campuses, and Communities," *IEEE Annals of the History of Computing* 36, no. 2 (2014): 88, 86–87.

12. Glenda Elizabeth Gilmore, *Defying Dixie: The Radical Roots Of Civil Rights, 1919–1950* (New York: W. W. Norton, 2008); Barbara Ransby, *Ella Baker and the Black Freedom Movement: A Radical Democratic Vision* (Chapel Hill: University of North Carolina Press, 2003); Katherine Charron, *Freedom's Teacher: The Life of Septima Clark* (Chapel Hill: University of North Carolina Press, 2009); Adam Rome, *The Genius of Earth Day: How a 1970 Teach-in Unexpectedly Made the First Green Generation* (New York: Hill and Wang, 2013).

13. Thomas J. Misa, *Digital State: The Story of Minnesota's Computing Industry* (Minneapolis: University of Minnesota Press, 2013).

14. Thomas J. Misa, "Digital State: The Emergence of Minnesota's High-Technology Economy," paper presented at the Massachusetts Institute of Technology HASTS Colloquium, Cambridge, October 22, 2012.

15. Sheldon Hochheiser, "An Interview with Donal Bitzer," February 19, 1988, Charles Babbage Institute, http://hdl.handle.net/11299/107121.

16. For more on time-sharing, see numerous articles in the *IEEE Annals of the History of Computing*, including the 1992 special issues on MIT time-sharing edited by J. A. N. Lee; Judy Elizabeth O'Neill, "The Evolution of Interactive Computing through Time-Sharing and Networking" (PhD diss., University of Minnesota, 1992); McDonald, "Building the Information Society."

17. Paul Ceruzzi, *A History of Modern Computing*, 2nd ed. (Cambridge, MA: MIT Press, 2003), chaps. 4 and 5; Martin Campbell-Kelly et al., *Computer: A History of the Information Machine*, 3rd ed. (Boulder, CO: Westview Press, 2014), chap. 6.

18. Dale LaFrenz, interview by Judy O'Neill, April 13, 1995, Charles Babbage Institute, http://www.cbi.umn.edu/oh/display.phtml?term=lafrenz&search=Submit.

19. Bonnee Fleming et al., eds., *Bisbila* (yearbook, University High School, Minneapolis, Minnesota), 1964, 12–13, box 4, collection 354, University of Minnesota Archives.

20. *University High School: A Report on the Purposes, Programs, Projects and Pupils of a Campus Laboratory School* (Minneapolis, Minnesota, 1967), 3.

21. LaFrenz, interview, 6.

22. John G. Kemeny and Thomas E. Kurtz, "Dartmouth Time-Sharing," *Science* 162, no. 3,850 (October 11, 1968): 223–28.

23. David C. Johnson et al., "Preliminary Report on Computer Mediated Instruction in Mathematics," February 1, 1966, folder for courses of study, box 1, collection 354, University of Minnesota Archives; LaFrenz, interview.

24. LaFrenz, interview, 7.

25. Johnson et al., "Preliminary Report."

26. Ibid.; David C. Johnson et al., "Preliminary Report #2 on Computer Assisted Mathematics Program, CAMP," December 1, 1966, folder for courses of study, box 1, collection 354, University of Minnesota Archives.

27. Johnson et al., "Preliminary Report," grade 9 section.

28. Ibid., grades 7 and 11 sections.

29. Larry L. Hatfield, "Computer Mediated Mathematics: A Ripple or a Wave?," reprinted from Minnesota Council of Teachers of Mathematics newsletter, May 1966, information file for University High School, University of Minnesota Archives.

30. Johnson et al., "Preliminary Report #2."

31. "Pillsbury Co. Purchases GE Computer," *Schenectady Gazette*, May 1, 1965, Saturday edition; "Pillsbury Forms Unit to Offer Wide Range of Computer Services," *Wall Street Journal*, January 16, 1968.

32. Johnson et al., "Preliminary Report #2."

33. LaFrenz, interview, 9.

34. Liz Burkhardt, ed., *Bisbila* (yearbook, University High School, Minneapolis, Minnesota), 1966, 15, box 4, collection 354, University of Minnesota Archives.

35. Reprinted in Johnson et al., "Preliminary Report."

36. Hatfield, "Computer Mediated Mathematics."

37. "Math Teachers Visit 'Vegas,'" *Campus Breeze* 49, no. 7 (University High School, Minneapolis, Minnesota, April 21, 1967), box 5, collection 354, University of Minnesota Archives.

38. Jo Freeman, "On the Origins of Social Movements," in *Waves of Protest: Social Movements since the Sixties*, ed. Jo Freeman and Victoria Johnson (Lanham, MD: Rowman & Littlefield Publishers, 1999), 7–24.

39. The joint board recognized early on that its name was rather "cumbersome," and it resolved to adopt Total Information for Educational Systems, with the acronym TIES, as its activity title "for the purposes of identifying more easily with Joint Board constituency and the general public." From "TIES Executive Committee Meeting Minutes," December 20, 1967, 5, folder for TIES committee minutes, box 1, collection 138, CBI.

40. Educational Research and Development Council of the Twin Cities Metropolitan Area, *Prospectus TIES: Total Information for Educational Systems* (Minneapolis: Educational Research and Development Council, 1967), numbered page 2. Not all pages in this document are numbered, so I am identifying them based on a page number when provided and section when there is no page number.

41. Ibid., pt. 5, sec. 4.

42. Ibid., introduction 1, numbered pages 3–4.

43. Ibid., numbered pages 9 and 33.

44. *TIES & TALES* 1, no. 2 (November 1967): 1.

45. Such meetings are mentioned, for example, in *TIES & TALES* 1, no. 5; 1, no. 6; 2, no. 1; 2, no. 2; 3, no. 1; and 3, no. 3.

46. *TIES & TALES* 1, no. 5 (June 1968).

47. *TIES & TALES* 4, no. 3 (February 1971): 7.

48. *TIES & TALES* 1, no. 1 (September 1967).

49. *TIES & TALES* 4, no. 7 (May 1972).

50. *TIES & TALES* 1, no. 4 (March 1968).

51. *TIES & TALES* 1, no. 6 (September 1968).

52. Ibid.

53. *TIES & TALES* 4, no. 5 (June 1971): 7.

54. *TIES & TALES* 3, no. 2 (April 1970): 5.

55. *TIES & TALES* 4, no. 3 (February 1971): 4.

56. *TIES & TALES* 4, no. 2 (December 1970).

57. *TIES & TALES* 4, no. 1 (October 1970): 9.

58. *TIES & TALES* 5, no. 2 (May 1973): 15.

59. Donald Holznagel et al., *Timely TIES Topics* 1, no. 1 (September 29, 1972).

60. Ibid.

61. LaFrenz, interview; Jessica Lussenhop, "Oregon Trail: How Three Minnesotans Forged Its Path," *City Pages*, January 19, 2011, online edition, http://www.citypages.com/content/printVersion/1740595/.

62. Donald Holznagel, Dale E. LaFrenz, and Michael Skow, "Historical Development of Minnesota's Instructional Computing Network," in *Proceedings of the 1975 Annual Conference* (ACM, 1975), 79–80, doi:10.1145/800181.810282.

63. Ibid.; Kathryn L. Nelson, "An Evaluation of the Southern Minnesota School Computer Project" (MS thesis, Mankato State College, 1971).

64. James Armin Sydow, "Secondary Athletics and the Computer," 1974, http://www.eric.ed.gov/ERICWebPortal/contentdelivery/servlet/ERICServlet?accno=ED096971; Sydow, "Computers in Physical Education," 1974, http://www.eric.ed.gov/ERICWebPortal/contentdelivery/servlet/ERICServlet?accno=ED096972; Ross Taylor, "Learning with Computers: A Test Case," *Design Quarterly*, January 1, 1974, 35–36, doi:10.2307/4090838.

65. Sydow, "Secondary Athletics."

66. Haugo, "MECC."

67. "January 22, 1973 Joint and Cooperative Agreement MECC," January 22, 1973, folder MECC 1972–73, box 58, collection 420, University of Minnesota Archives.

68. Ibid.

69. Ibid.

70. Peter Roll, "A Brief Report on the Status of Planning for the Minnesota Educational Computing Consortium (MECC)," February 6, 1973, folder MECC 1972–73, box 58, collection 420, University of Minnesota Archives.

71. MECC, *Systems Update* 1, no. 2 (June/July 1974).

72. Ibid.

73. Ibid.; and 1, no. 3 (October 1974).

74. MECC, *Systems Update* 1, no. 2 (June/July 1974): 1.

75. Holznagel, LaFrenz, and Skow, "Historical Development."

76. Ibid.; MECC, *Systems Update* 1, no. 3 (September/October 1974); and 2, no. 1 (January/February 1975).

77. MECC, *Systems Update* 1, no. 3 (September/October 1974): 1–2.

78. MECC, *Systems Update* 1, no. 4 (November/December 1974): 1.

79. MECC, *Systems Update* 1, no. 3 (September/October 1974): 1–2.

80. MECC, *Systems Update* 1, no. 2 (June/July 1974): 1.

81. Ibid., 1–2.

82. MECC, *Systems Update* 2, no. 1 (January/February 1975): 3.

83. Donald Holznagel et al., *Timely TIES Topics* 2, no. 7 (March 1974): 4.

84. Donald Holznagel et al., *Timely TIES Topics* 2, no. 6 (February 1974): 2.

85. Ibid., 3.