The Future of the History of Computing

Working Group 9.7: History of Computing

Christopher Leslie(✉)

Prince of Songkla University, Hat Yai, Thailand
christopher.l@psu.ac.th

Abstract. Founded in 1992, IFIP Working Group 9.7 is dedicated to three themes in the history of computing: pedagogy, regional/transnational histories, and public engagement. The synergies among the three suggest a novel aspect of the working group. For instance, local museums and archives can improve the stories about regional histories. What is more, educators can enhance the experience of their students by using museums and archival materials in the classroom. Our future work will be to increase our visibility in these three domains, developing pedagogies that use museum and archival collections, helping to overcome some of the biases that prevent engagement with solutions to climate change, and enhancing attention to diversity, equity, and inclusion.

Keywords: History of Computing · Archives · Museums · Pedagogy · Regional Histories

International Federation for Information Processing (IFIP) Working Group 9.7 (WG 9.7) facilitates interdisciplinary conversations to provide a robust history of computing. We are uncomfortable with the notion that a computer is an opaque box lacking a history. We welcome technical practitioners in computer science and information technology who have an interest in history, academic historians who have an interest in computing (from various fields, such as history and the social sciences), public historians, and archivists (including those at corporations). Technical experts in information and computer technology (ICT) benefit from academic discussions about analyzing and preparing historical materials. Simultaneously, professional historians benefit from an audience better versed in technical details. Our heterogeneity means that all members benefit from complementary competencies.

Because it is part of IFIP, WG 9.7 is different from other professional groups dedicated to the study of computing. IFIP's technical committees are strongly connected to computing professionals and technical experts, so we are imbricated with technological culture. IFIP's decidedly international character ensures we draw our members from a cosmopolitan coalition. Finally, because we are situated within TC 9, we benefit from interactions with other working groups and their focus on ethics, diversity, and sustainable development.

As detailed below, WG 9.7's activities fall into three broad focus areas: pedagogy, regional/transnational histories, and public engagement. Anyone interested in the history

Published by Springer Nature Switzerland AG 2024
C. Leslie and D. Kreps (Eds.): *Current Directions in ICT and Society*, IFIP AICT 700, pp. 89–107, 2024.
https://doi.org/10.1007/978-3-031-50758-8_6

of computing is welcome to participate. However, the group's most compelling work is providing case studies, public outreach, and educational opportunities that support the international scope of the development of computing. In this way, synergies among the three focus areas are clear: for instance, the work done by museums and archives supports research into regional histories, and the desire to document teaching experiences in widespread contexts often results in contributions to museum collections and calls for international accounts of computing. WG 9.7's activities differ from other national and international research groups due to its cosmopolitan membership and the reinforcing action shaping the three focus areas.

1 Goals and Activities

WG 9.7 recognizes that there are few training opportunities in the history of computing, let alone the history of technology. In fact, generalist histories often take the computer as given and focus on the completed product's use in affluent societies. Due to a lack of public understanding of the history of technology, misinformation about the history of computing can easily be perpetuated. It is all too easy to draw a simplistic line of causation and lineal progress connecting Gottfried Leibniz, Ada Lovelace, Colossus, Alan Turing, Grace Hopper, SAGE missile defense, the various people claiming to be the "father" of the Internet, etc. WG 9.7 aims to promote historical awareness that returns the contingency and human values to these stories. This is not to say that we are all in agreement, but we are unified in bringing wider attention to good scholarship and creating a platform for new developments.

WG 9.7 believes that a better understanding of the history of computing helps us understand our society's current status and various social issues. Shedding light on the path of innovation that brought about our contemporary computing culture, we promote and broadcast essential aspects of the history of computing and why they are relevant today. History provides context for current initiatives. In addition to documenting the path of innovation, we also are interested in the paths that should have been taken. This analysis demonstrates the social mechanisms through which potential can be lost. For instance, we can show the success of the Web as opposed to more powerful hypermedia models available at the time that have since been forgotten, teaching children using textual languages instead of visual programming language paradigms, and so on.

Our primary activity is our English-language workshops, typically held every other year. The topics for our workshops have resulted in accessible, go-to reference works in English on the history of computing in various regions. In this effort, we seek to promote a better understanding of the social impact of computing. Within the broad historical trends in computing technology and practice development, we examine the role of industry, national governments, and the international community in guiding research, setting standards, and conceptual and technical innovations of use to practitioners. Students and faculty in computing and related fields, such as electrical engineering, need to know the basics of the history of computing that has a consensus. Within IFIP, WG 9.7 seeks to promote historical awareness. IFIP has played an essential role in the international development of technical standards and new technical solutions. Given the fast pace of change in the development of technology, historical action may be quickly lost or

forgotten. Thus, the group has an opportunity and obligation to preserve the historical memory of the professionals in IFIP.

Our practice has been to require draft papers for potential workshop participants. A panel of peer reviewers makes decisions about acceptances and provides comments to the authors. About a month before the workshop, authors circulate their revised drafts to ensure a lively conversation at the workshop. After the workshop, authors have a few weeks to revise their papers before submitting them for consideration in the hard-cover anthology of selected, revised articles, which Springer Nature currently publishes. In addition to the workshop and resulting proceedings volumes, members keep in touch more spontaneously, sometimes under the auspices of national computer societies. E-mail communication by the group provide an important outreach about upcoming opportunities and keep the conversation going. We all benefit from a platform that allows us to exchange experiences and seek advice from a group with a global perspective.

2 Brief History of WG 9.7

2.1 Prehistory and Formation

The founding chair of WG 9.7 was John A. N. Lee, a professor of computer science at Virginia Polytechnic Institute. He was one of the people in the 1970s who first defined the history of computing as a field. At this early stage, the history of computing was conducted by computing professionals who wished to improve research outcomes by applying history. Looking back on those years when electronic computers were barely thirty years old, Lee [1] points out that the history of any aspect of computer science could be told relatively succinctly. Also, it was possible to face disdain from colleagues who felt that anyone interested in history, social consequences, or pedagogy was past their prime, given the belief that computer science was about inventing the future. Institutionally, organizations like university archives had the opinion that computer science was not old enough to need historical treatment.

In 1973, one of the first attempts to establish the history of computing was the Los Alamos Conference on the History of Computing in the Twentieth Century. Nick Metropolis was the organizer, and Richard Hamming offered a keynote. In 1978, Lee was the administrative chair of this conference, a member of the program committee, and chair of several panels for the first ACM SIGPLAN History of Programming Languages (HOPL) held in Los Angeles. Grace Hopper was the keynote speaker [1]. An outgrowth of the Los Alamos conferences, it was the first history conference organized by a professional society [2]. As much as possible, these early conferences moved away from a simple chronological list of events and sought to record what practitioners were thinking and the context for their decisions.

Lee's involvement with IFIP came about indirectly through the American Federation of Information Processing Societies (AFIPS), the U.S. representative when IFIP was founded. AFIPS was also an early sponsor of the history of computing. For instance, between 1967 and 1974, AFIPS contributed $130,000 to the Smithsonian, which was used to collect oral histories [3]. Starting in 1974, AFIPS began a tradition of Pioneer Days at their National Computing Conference (NCC). Each day was organized around a particular theme and invited participants to speak about their experiences. Twelve

of these workshops were organized under the auspices of AFIPS. A group of organizers for each year's Pioneer Day conducted a "research program" that culminated with a "mini-conference" [4]. The first Pioneer Day was devoted to the Dartmouth Time-Sharing System and BASIC. In 1979, AFIPS published the first *Annals of the History of Computing* issue. Lee organized the AFIPS's Pioneer Day in 1982 to celebrate the twenty-fifth anniversary of FORTRAN at the NCC meeting in Houston (Fig. 1). Lee then co-edited a special issue of *Annals* based on this event in 1984 (vol. 6, iss. 1). As AFIPS turned over publication duties to Springer-Verlag in 1987, the founding editor also stepped down. Lee took over as editor of vol. 9, iss. 2, a position he would hold for nine years.

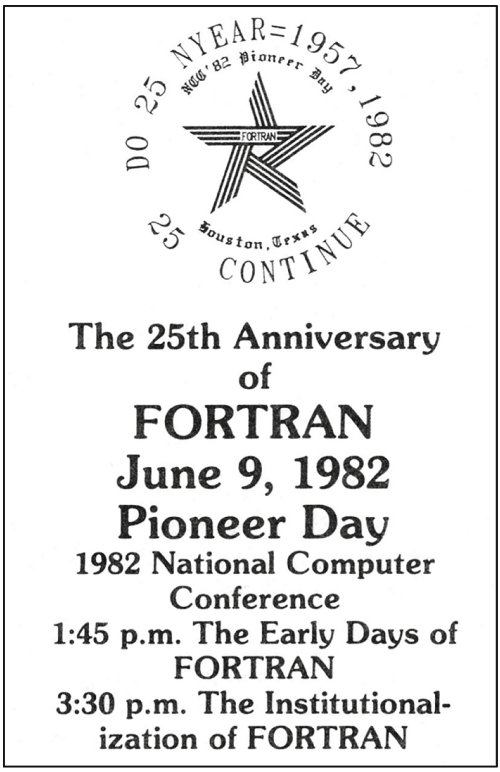

Fig. 1. Advertisement for an early Pioneer Day celebrating FORTRAN

At the end of his term, the *Annals* published a special issue in 1996 edited by Betty Campbell to commemorate the fiftieth anniversary of ENIAC. Dedicated to women in computing, the five articles ran from Ada Lovelace to the future synergy between women's studies and computer science [5]. At that time, computer science faculty were often members of mathematics or science departments. Computer science experts were already facing a credibility problem – computing was often considered an auxiliary task by skilled staff, not an academic discipline.

AFIPS, which had been the representative of the United States in the formation of IFIP in 1960, was itself an umbrella organization for three groups: the Association for Computing Machinery (ACM), the American Institute of Electrical Engineers (AIEE), and the Institute of Radio Engineers (IRE). The latter two merged in 1963 to form the Institute of Electrical and Electronics Engineers (IEEE). AFIPS abruptly dissolved in 1990, leaving behind its constituent organizations. IEEE took over the publication of the *Annals*, and ACM took over AFIPS's position as the United States delegate for IFIP.

When AFIPS ceased its activities, Pioneer Days no longer had a venue. Consequently, Lee approached IFIP's Technical Committee 9 as a possible sponsor. In 1992, TC 9 formed a new working group, 9.7, which would be responsible for Pioneer Days and have Lee as chair. As seen in Fig. 2, six more Pioneer Days were organized for the hosts of IFIP's World Computer Conferences to promote their countries' contributions to the history of computing, and the many years of coordinating recognition of important figures in the history of computing led Lee to publish an anthology, *Computer Pioneers,* in 1995.

Year	Description
1994	Germany, honoring Konrad Zuse
1996	Australia
1998	Austria/Hungary, Mailüfterl (May Breeze) computer in 1958
2000	China
2002	Montreal
2004	France

Fig. 2. WG 9.7 Pioneer Days at IFIP World Computing Conferences.

2.2 Expansion

The second chair of Working Group 9.7 was John Impagliazzo, who was also an early promoter of the history of computing. In 1988, he organized a conference on the legacy of John von Neuman at Hofstra University. He then began to incorporate history into his computing classes [6]. Impagliazzo invited Lee to be a speaker at a 1996 ACM conference on computing education. That same year, at the WCC in Australia, they devised a plan to create a guide for teaching history as part of the computing curriculum. Impagliazzo became the chair of an ad-hoc committee to create a report; the other members were Lee; Gordon Davies, the chair of IFIP TC3 on education; and historians Michael Williams and Martin Campbell-Kelly. The final report, approved by TC 3 and TC 9 in 1998, was entitled "History in the Computing Curriculum" and published in the *IEEE Annals of the History of Computing* the following year.

Impagliazzo took over as chair of WG 9.7 in 2001. At the time, there were only a few members. Impagliazzo, though, had a vision of widening the membership. Starting in 2003, he organized the first WG 9.7 workshop. As seen in Fig. 3, this resulted in a series of workshops focused on Nordic and Soviet computing and workshops on computing education.

Year	Description	Editors
Education and Computing		
1998	History in the Computing Curriculum IFIP TC3 / TC9 Joint Task Group *Annals of the History of Computing*, January 1999	John Impagliazzo
2004	"History of Computing and Education" World Computer Congress, Toulouse, France	John A. N. Lee, John Impagliazzo
2006	"History of Computing and Education 2" World Computer Congress, Santiago, Chile	John Impagliazzo
2008	"History of Computing and Education 3" World Computer Congress, Milan, Italy	John Impagliazzo.
2014	"Reflections on the History of Computers in Education: Early Use of Computers and Teaching about Computing in Schools"	Arthur Tatnall, Bill Davey
Nordic Computing		
2003	"History of Nordic Computing" Trondheim, Norway	Janis Bubenko, John Impagliazzo, Arne Soelvberg
2007	"History of Nordic Computing 2" Turku, Finland	John Impagliazzo, Timo Järvi, Petri Paju
2010	"History of Nordic Computing 3" Stockholm, Sweden	John Impagliazzo, Per Lundin, Benkt Wangler
2014	"History of Nordic Computing 4" Copenhagen, Denmark	Christian Gram, Per Rasmussen, Søren Duus Østergaard
Computing in Russia and Eastern Europe		
2006	"Perspectives on Soviet and Russian Computing" Petrozavodsk, Russia.	John Impagliazzo, Eduard Proydakov
2018	"Histories of Computing in Eastern Europe" 24th IFIP World Computer Congress in Poznań, Poland	Christopher Leslie, Martin Schmitt
Generalist and Public Engagement		
2010	"History of Computing: Learning from the Past" Brisbane, Australia	Arthur Tatnall
2012	"Reflections on the History of Computing: Preserving Memories and Sharing Stories" Survey Subline of IFIP AICT	Arthur Tatnall
2013	"Making the History of Computing Relevant" London, England	Arthur Tatnall, Tilly Blyth, Roger Johnson
2016	"International Communities of Invention and Innovation" New York City, United States	Arthur Tatnall, Christopher Leslie

Fig. 3. Working Group 9.7 workshops and publications

During Impagliazzo's tenure, WG 9.7 membership increased from six to sixty members [6]. The protocol of the early days when Lee was chair persisted, with each workshop continuing the collaborative process. Draft papers were circulated before the workshop,

and participants received comments from their peers that they could use to revise their papers for the post-workshop proceedings.

In 2007, Arthur Tatnall took over as chair of the working group, presiding over a successful workshop in Brisbane and another at the London Science Museum, which included an excursion to Bletchley Park. In 2012, Tatnall edited the first "survey" volume in the Springer subseries of AICT; a second volume of this type appeared in 2014 (see Fig. 1). Tatnall recruited the current chair, Christopher Leslie, to host a workshop at New York University. Participants in this workshop visited Google's New York offices and Nokia Bell Labs in New Jersey. Leslie became chair in 2017 and oversaw a workshop about computing in eastern Europe concurrent with IFIP's World Computer Congress in 2018. The group's plan for the 2020 workshop focusing on the history of computing in Asia has been delayed by COVID-19.

3 WG 9.7 Themes

The group has focused on three focus areas: pedagogy, regional/transnational histories, and public engagement. Our workshops and proceedings volumes typically offer papers from all three themes.

3.1 Pedagogy

One of the first publications from WG 9.7 was the report of the history task force, which was published in the *Annals* in 1999 [7]. At the time, some professional associations had guidelines regarding including social contexts or ethics of computing for computer science undergraduates. Still, these guidelines should have paid more attention to the history of computing. The report advocated the inclusion of standalone courses or modules for students studying computing and history of computing courses for students outside of computing majors.

At the time, few full-length books were suitable for this endeavor – such as Augarten [8], Campbell-Kelly and Asprey [9], Freiberger [10], Levy [11], Pugh [12], Williams [13], and Stern [14] – so the report authors advocated for the inclusion of articles from the *Annals* to supplement coursework. This early pedagogical consideration sought to develop a basic curriculum that briefly but accurately covered the fundamental themes of history, suitable for introductory or even advanced computer science or electrical engineering courses. From the start, it was clear that history could be incorporated into computing curricula in several ways, including developing online resources [15].

The pedagogical angle of WG 9.7's activities can be construed in one of two ways. The initial focus was on how history can be used in the training of computing professionals. Soon, though, the chronicle of how computing was introduced as a discipline became an additional focus. These two topics overlap to a certain extent. The study of how and why computers were introduced as a topic of study in universities, for instance, is not quite the same as how computers developed as a technology. The history of attempts to educate computing students has resulted in amazing stories at WG 9.7 workshops over the years. For instance, Szabó [16] documented how "chalk programming" was used to overcome the lack of computers at the University of Szeged in postwar Hungary.

The proceedings volumes have, to a certain extent, fulfilled the desire of John A. N. Lee and John Impagliazzo to have resources for teaching and learning about the broad history of computing. Consider how these clusters of articles could improve the understanding of computing for undergraduates:

- A pair of articles on the Nordic project to computerize graphic production in the 1980s [17, 18]. Following their desire to include workers in all phases of the innovation process, computing professionals worked with the workers who would eventually use this system. Pelle Ehn's use of simulated "cardboard computers" is an excellent example of what has come to be known as participatory, democratic, or feminist design.
- A collection of articles considering the complexity of technology transfer and the failure of determinist notions about technology, which suggests that devices are inseparable from their social contexts. Sikora, for instance, writes about Poland's unenviable position in the middle of CoCom and COMECON countries [19]. Leslie describes the failure of determinist interpretations of technology transfer that informed CoCom [20].
- A set of articles about international experiences. Jiménez et al. [21] write about computer science in Cuba before 1990. Torro writes about the early use of computers in Chilean education [22].
- The importance of international collaboration in the development of the Internet. Lundh [23] and Spilling [24] discuss early TCP/IP connections to Norway.
- A cluster of articles about the history of international collaboration in computing. Fet [25] describes Norbert Weiner's visit to Russia in 1960. Dittmann [26] describes an experimental network connection across the Iron Curtain in 1977, when the U.S. conducted the three-network test that was the proof of concept for TCP/IP. Schmitt [27] writes about when East Germany imported a U.S. army computer for its financial system.

3.2 Regional and Transnational Histories

Because of the international makeup of IFIP, WG 9.7 has successfully incorporated non-US participants into the overall history of computing. Our proceedings volumes record events that are only sometimes submitted to other venues. They also challenge preconceptions lurking in the background of other well-known works. Significantly, these English-language volumes facilitate international conversations, helping scholars from different countries become aware of significant developments and new thinking that might be harder to access if published in local languages.

The proceedings of WG 9.7 workshops are not comprehensive volumes that provide authoritative overviews of computing. As such, they do not purport to orient readers to a single interpretation of the field; the only organizing theme is a desire to broaden the understanding of the history of computing, resulting in a reference work with an assortment of points of view. Although they may need a more comprehensive scope, in an impressionistic fashion, they provide insights not available elsewhere and citations to texts that can help new research in the field. The various national settings allow us to reconsider the importance of national projects that need to be more well-known internationally.

One important lesson from these local histories is how national and regional priorities influence what kind of computing projects are funded and attempted. For instance, perusing the four volumes of Nordic Computing proceedings shows the region's commitment to human welfare when SAGE was adapted for the SABRE airline reservation system. These volumes document the many uses of time-sharing systems for purposes related to socialized medicine, such as patient information, prescriptions, reporting of test results, and more, long before the Internet came to be. These stories serve as a reminder of the cultural pull on innovation, providing funding and leadership for projects that fit in with a region's ideological priorities.

Another critical theme running through the regional WG 9.7 workshops is reconsidering the notion of failure. Telling the history of computing from a core to the supposed periphery leads to the impression that the success of companies like IBM and networks like the TCP/IP Internet resulted from a technical equivalent of natural selection. WG 9.7 papers challenge this simplistic notion of a one-way transfer of technology and the nationalist bias in histories that presume there are simple winners and losers in the technological ecosystem. For instance, at the first Nordic computing workshop, Petri Paju [28] argued that the supposed failure of Finland's ESKO computer project should be reconsidered. To some, Paju notes, the single computer that emerged in 1960 was "out-dated" (p. 80) or "irrelevant" (p. 81). The fact that IBM exported working computers to Finland has led to that company's assertion that they were the progenitor of Finland's computing industry. Paju counters with observations about how the project trained the first group of computing experts in the country, who were then available for other projects, helping to provide IBM Finland with workers that helped them become the country's biggest supplier of computing services. Additionally, an offshoot of this project "evolved into the Electronics Department of the Nokia Company" (p. 93). In the same volume, Carlsson [29] notes that Sweden's effort to develop computing devices in the early years might be viewed as a failure because it did not result in a national computer industry. However, another viewpoint is that computers were tools for establishing computing practices. Early computing as a social activity, where experts studied, learned, and met with international counterparts, were successes. In this way, the research helped universities develop expertise in training programmers and setting up organizations. He concludes:

> I wish to stress the importance of seeing the computers as tools for the renewal of the engineering profession and of scientific research and the society as a whole in the years immediately after World War II, rather than techno-scientific ends in themselves or, for that matter, as purely military tools. [30, p. 106]

This theme has often been repeated. For instance, in the 2018 workshop in Poznan, Kitova and Kitov [30, 31] challenged the notion that computing in the former Soviet Union was a failure. The "InterNyet" concept [32], as alluring as it might be, does not fit the lived experience of computing in the USSR. By studying the insights offered by WG 9.7 workshops, one sees that the proliferation of devices and market dominance are not the sole criteria for success or failure.

One way WG 9.7 workshops challenge popular thinking in the history of computing is that technological devices are only transported from one national context to another with

adaptation and development. For instance, one consistent theme in the Nordic Computing workshops was how interaction with IBM had indirect and unexpected consequences. Imported computing technology must be modified to fit local contexts. In this way, the papers published in WG 9.7 can help improve the understanding of technology transfer.

The tendency to think of computing and the Internet as primarily a result of U.S. innovations has resulted in a bias in typical histories. However, this predisposition provides WG 9.7 members an opportunity to rethink those stories. Tatarchenko [33], for instance, points to a 1966 cooperation agreement between France and the USSR, which fit in with both countries' desire to break through U.S. hegemony in computing. The first-person accounts in our proceedings volumes describe how innovation and technology transfer occur. Baehrs [34], for instance, describes the MRAMOR Workstation for the production of *Pravda.* Other phototypesetters were inadequate for the Russian language and, for that matter, the language of other Soviet countries. The new system could produce magazines in different languages on one workstation.

These regional and transnational narratives serve an essential function. As computers become ubiquitous and integrated with daily life, it is crucial to build up stores of narratives that help people understand their significance and contingency. Like any other technical achievement, computing technology is not developed in a vacuum. Local pressures and interests impact its development, which is an important lesson for future innovators and analysts of computing devices.

3.3 Public Engagement

The third broad theme addressed by Working Group 9.7 relates to efforts to educate the public about the history of computing. Many WG 9.7 workshops have papers from museum curators and other professionals interested in the public understanding of computing history. Still, a few workshops and proceedings volumes consider this theme in full.

In 2013, the Working Group sponsored a robust, well-attended workshop at the London Science Museum, which Google sponsored. In addition to paper presentations, delegates could view an exhibit about Alan Turing at the museum. Delegates also visited Bletchley Park, the site of England's codebreaking team during World War II and now the home of the National Computing Museum. We saw a demonstration of the (rebuilt) Colossus computer designed to crack wartime ciphers there. This allowed historians to learn about the opportunities and challenges related to engaging the public with the history of computing. The proceedings volume [35] contains many papers associated with curating museum exhibits, using primary sources, and utilizing artifacts for public education.

Other proceedings volumes contain papers helpful in developing or managing museum collections outside well-known institutions like the London Science Museum or the Computer History Museum in Mountain View, California. Among several papers at the second History of Nordic Computing workshop was a paper describing the collaborative effort to preserve source materials relating to Swedish computing from 1950 to 1980. The author noted the committee structure used to negotiate between the practitioners and historians [36]. Another example of this type of paper is a survey of strategies for gaining funding for computer history museums conducted to aid institutions in Latvia. It

also provides insight to professionals at any organization hoping to expand the scope of their support [37]. In this way, WG 9.7 workshops help professionals with networking and information sharing that can help support the international history of computing.

In tandem with Working Group 9.7's regional histories, our support for international museums and exhibitions is essential to preserve the many efforts at computerization that might otherwise fall by the wayside. For instance, the Monash Museum of Computing History preserves the MONECS project, which successfully provided hands-on programming experience to students when there were limited computing resources in the 1970s [38]. Similarly, the Polytechnic Museum in Moscow holds the only extant Ural-1 computer, one of hundreds of devices developed in the 1960s in the shadow of CoCom export restrictions that prohibited technology transfer to countries aligned with the Soviet Union [39]. Through our workshop proceedings, one can learn about collections and archives that contain relevant research material that cannot be obtained elsewhere.

To reach a broader audience, our delegates have described their efforts to establish virtual museums, creating opportunities for the international community to use archival and other materials to expand their historical analyses. Edward Proydakov's Virtual Computer Museum, created in 1997, and other online sites were described in 2009 [40]; an update on this project was provided on the site's twentieth anniversary [41]. The curators of these resources state their importance directly: one reason to construct virtual museums of computing history is that a western perspective often dominates classrooms, leaving out perspectives on Soviet and eastern European computing. Through the Web, the curators hope to make a broader range of research material available to historians interested in international histories [42]. The imprimatur of major institutions and the ease of access afforded by the Web should make it more likely that these resources will be used.

4 Future Directions

The delegates to Working Group 9.7 expect our future activities to remain within the three focus areas that have been its core competencies, even though we know that we must adapt and improve. Examining the history of the working group provides clues to how we can improve the history of computing with a flair particular to the already established traditions. In addition, we will benefit from the other working groups in Technical Committee 9 and the committee's leadership overall.

4.1 Increasing Breadth and Visibility

Working Group 9.7's workshops and proceedings volumes have added depth and complexity to the historical study of computing. A goal for the coming years should be to increase the scope and impact of this research.

To be truly international, WG 9.7 must continue its effort to broaden the locations and topics of its workshops. Partnering with IFIP member societies in each country is a reasonable approach, as well as tapping our delegates to serve as hosts. The lessons learned during the COVID-19 pandemic have clarified that hybrid conferences are viable

and allow participation from people who find it difficult to travel. Although in-person meetings provide some advantages for networking, it would be possible to invite professionals from various regions to share their research even if they cannot attend in person.

Regarding greater visibility and a higher number of citations, the WG might consider guest-edited editions of relevant academic journals for selected papers from its workshops. Our proceedings volumes consist of selected, peer-reviewed articles. They are published in Springer's Advances in Information and Computer Technology, ranked by SCI (in the subsets SCIE and SSCI [43]). Even though our members produce excellent work, including the word "proceedings" in our volume titles precludes some academic departments from considering the publications for appointments and promotions. WG leadership should work with the delegates who have advanced research to publish shorter, workshop versions of their papers in the proceedings and then expand and revise papers in relevant journals.

4.2 Archives and Museums in STEM Curricula

The constituent groups of WG 9.7 – with innovation in history, pedagogy, and public engagement – demonstrate novel synergies that can provide insight into future work. Using artifacts found in museums and archives not only can improve scholarly work but also have the potential to improve students' experiences in the classroom.

The so-called maker culture has captivated the attention of programs seeking to educate the next generation of scientists and engineers. Students in science and engineering are now accustomed to more hands-on, project-based activities. Finding ways to do so in the humanities is necessary for the history of computing to remain accessible to those student populations. A tempting line of inquiry could lead to innovation in teaching history. Archive-based research is also an avenue.

Delegates to WG 9.7 have already been forging a path into this domain. In recent years, WG 9.7 members have shown innovation in how teaching can use history. For instance, at the 2013 London workshop, Cignoni and Gadducci [44] described their techniques for using older computers in education through rebuilding or simulation. Breaking new ground in historical awareness, some members of our group are part of the rising wave of "retrocomputing," i.e., the rise of retro machine clubs, websites, and YouTube channels. We promote the use of growing museums and extensive private collections. Museums and significant private collections are growing, and the prices of machines with parameters lower than the modern refrigerator reach thousands of dollars at online auctions [44, 45]. Using historical artifacts also interesting in the way they show how contexts and definitions shape development [38, p. 116].

Using archival material to improve STEM education is another possibility already considered. This modality is particularly intriguing given the work by WG 9.7 delegates to digitize and promote their archival collections. The present author has demonstrated using archival material in classes for engineering students (e.g., suggestions for classroom use are found in [46]). These activities do not have to be sponsored by large entities; [47] describes efforts originated by a university archivist with ordinary institutional holdings. Librarians and archivists have increased their attention to the aspects of

their collections that might interest STEM educators [48]. This could and should lead to crafting more innovation in the history of computing classrooms.

In this domain, the working group recognizes that all entities have a role to play. Indeed, extensive, established computing museums often started as small collections. Smaller collections, therefore, have critical aspirational goals. In addition, many smaller groups do important, regional STEM outreach that larger institutions cannot. WG 9.7 welcomes contributions from these entities, encouraging them to learn from each other and working historians. In addition to their role in STEM outreach, hobbyist groups and smaller collections can capture local narratives that might not otherwise be recorded and preserved.

This theme offers possible synergies with IFIP TC 3.

4.3 Computing Histories in the Anthropocene

TC 9's Human Choice and Computers 14 conference with the theme "This Changes Everything" made it clear that there is vigorous interest in topics at the intersection of sustainability and ICT [49]. This urgent theme should be one aspect of WG 9.7's future work. Historical studies have an essential role to play: ensuring that the histories we tell prepare our audiences for the collective, long-term efforts required to face climate change.

Geologists have proposed that human activity has dramatically impacted the current epoch and that a new period should be named the Anthropocene. Although there is no current consensus on when this period began – human activities as early as the cultivation of crops to as late as the detonation of nuclear weapons have been proposed [50] – the impact of human activity has outpaced the forces of nature. The Anthropocene is marked by the loss of biodiversity, rising sea levels, and the release of greenhouse gasses by cultivating livestock and burning fossil fuels.

The history of computing might seem far removed from these biological and geological concerns, but scholars in the humanities have pointed out how historical methodologies need to be revised in order to generate support for global, multi-generational action. Helping people adopt a mindset encompassing geologic timeframes can be a role for the humanities. Some critics, like Chakrabarty [51], suggest that typical historical approaches must be reexamined in light of the planet's challenges. Metanarratives about the emergence of the modern individual and human freedom coincide with the increasing use of fossil fuel: "Our freedoms so far have been energy intensive." Chakrabarty suggests that the path into the Anthropocene was not inevitable. Still, now that humanity has arrived, "the way out of our current predicament cannot but refer to the idea of deploying reason in global, collective public life" (pp. 32, 34). The sense of progress, including technological progress, is tied up with the exploitation of the planet, even though only fifteen or so nations representing just one-fifth of humanity are "historically responsible for most of the emissions of greenhouse gases" (p. 57). One thing needed to tackle this situation is understanding that the connection between globalization and fossil fuels was a technological choice by a small swath of humanity, not an inevitable stage in the globe's development. Historians of technology have the opportunity to describe this notion of choice and inculcate an appreciation for the consequences of choices.

Ghosh [52] has made further suggestions on how the humanities could better equip world citizens to face the challenges of the Anthropocene. He evokes the notion of "derangement" to describe how little the humanities shed light on the planet's crisis. Imagining a future time when the consequences of climate change will be keenly felt, he warns scholars and artists that future citizens are likely to look back on present-day works of art and the humanities as "modes of concealment that prevented people from recognizing the realities of their plight" (p. 11). To prevent this occurrence, Ghosh makes a critique of the ways novels conceal the climate crisis: settings are concealing when they suggest each location is isolated from the rest of the world, and actions are concealing when they can be resolved within a few years of an individual's lifespan. These insights can be extrapolated to the practice of history.

Modern science and technology studies, emphasizing continuities and non-linear development paths, fit in with Ghosh's suggestion that the arts and humanities should promote a sense of interconnectedness, breaking national boundaries. Stories based on individuals in isolated environments reflect and reinforce the loss of collective destinies. He writes, "The acceleration in carbon emissions and the turn away from the collective are both … effects of that aspect of modernity that sees time [as] … a continuous and irreversible forward movement, led by an avant-garde" (p. 79). The current "carbon economy" that is precipitating the climate crisis is not unified. However, it is characterized by "admixture and interbreeding" (p. 108). Ghosh's insights are consonant with any history of technology, especially when incorporating insights from discussions seen in WG 9.7. Our proceedings volumes are full of papers describing how technological progress is not inevitable but interconnected, characterized by many efforts across time from people all over the globe. There is little feeling that individuals in a few elite countries created disruptive innovations and that individuals in other countries had no innovative contributions. Scholars also enjoy pointing out precursors to current devices, demonstrating the influence of multi-generational efforts. These themes deserve greater emphasis moving forward. The future history of computing should encourage historical analysis that shows the long-term, concerted effort in technological advance.

Scholars can and should also draw attention to how imperialism's inertia impacts technological development and exacerbates inequality. As an exemplar, consider the work of Starosielski [53], who was a guest speaker at our New York workshop. The network of undersea cables that is the backbone of international ICT follows the lanes of former shipping and communication networks. This legacy can be used to show how modern infrastructure, at the very least, benefits from former carbon-intensive activities.

The culture surrounding undersea cables challenges thinking that these regions are on the periphery of technological development. Craig Santos Perez, a poet born in Guam, has expressed his distrust for emotional responses to vulnerable island nations' plight. They are not "simply victims of the Anthropocene," Perez [54] writes; "the islands have produced, and continue to produce, the Anthropocene." Because of their relative isolation and low visibility, the islands have repeatedly been used to support planet-changing human activities such as "plantations, nuclear testing grounds, military bases, extraction sites, etc." (p. 430). Guam's history has been intertwined with globalization, initially as a waystation for ships crossing the Pacific where they could resupply themselves with coal. The first trans-Pacific telegraph cable was laid in 1903, running through Guam. The

island's historical role as a waypoint meant that Guam became the telecommunication juncture between the U.S. and China, the Philippines, and Japan in the Internet era. Santos writes that bringing attention to this legacy can be an impetus toward the islands' sense that their communities can impact technological choice.

As seen in the other chapters in this volume, Anthropocene studies suggests future collaboration with WG 9.2 and WG 9.9.

4.4 Diversity, Inclusion, and Equity

Another place where WG 9.7 is poised to lead histories of computing is the recent efforts to support diversity, equity, and inclusion (DEI) in the professions, particularly in science and engineering. A curious fact about diversity in computing is that many women were involved in the advent of digital computers. Soon, they were systematically denied access to the professions by degree requirements and other professional hurdles (for an overview, see [55]). Kleiman [56] has recently published a study of the women who made ENIAC a practical success. Historians and other humanities professionals are well-positioned to address DEI in concert with other efforts in their domains.

DEI has not been an explicit theme of the group, but it is clear that it has been on the minds of delegates. The first chair of Working Group 9.7, John A. N. Lee, started his career as a civil engineer and needed the help of a computer – a woman with a calculating device – to complete his research. Looking back on those days, Lee remembers how he failed to give credit in his thesis to the woman who did the calculations to solve the partial differential equations he relied on [5]. His work to correct mistakes in computing history, including his effort to remind the profession that women like Ada Lovelace and Grace Hopper played irreplaceable roles in computing, coincided with the early years of WG 9.7.

In addition, one can find papers that shed light on this theme in the proceedings volumes. For instance, the first workshop on Nordic Computing included the personal reflections of the first woman in Sweden to receive a Ph.D. in information science in 1979. Lindencrona [57] points out that, as she was looking for her first job, it seemed like there was an "implicit or explicit" assumption that men would have long-term careers, but this was not true for women. Also, papers about providing educational access through computers are implicitly, although not always directly, tied to a desire to support DEI. Those themes could be directly addressed in the future.

The history of computing also allows us to enhance the understanding of DEI. For instance, the U.S. notion that white and Asian men are disproportionately represented in science, engineering, and computing needs some nuance. This truism may apply to students, professors, and professionals with ties to China, India, Korea, and Japan. Nevertheless, it must be revised when considering individuals from southeast Asia (e.g., Cambodia, Thailand, and Laos). Although the latter are in Asia, their engineers find different success in obtaining access to education and jobs. Regional histories can play a role, then, in helping to refine the understanding of inequality and shape efforts to ameliorate it.

This future work indicates an opportunity to collaborate with Working Group 9.8 (Gender, Diversity, and ICT). Also, working with Working Group 9.4 (Social Implications of Computers in Developing Countries) would be beneficial.

Acknowledgment. The author is grateful for comments, suggestions, and editorial support from Nadia Ambrosetti, David Burger, Paul Ceruzzi, Martha E. Crosby, Marek Hołyński, Mary E. Hopper, John Impagliazzo, Frank Land, John A. N. Lee, Simon Lavington, Tomas Ohlin, Allan Olley, Mai Sugimoto, Máté Szabó, Arthur Tatnall, and Chris Zielinski.

References

1. Lee, J.: "Those who forget the lessons of history are doomed to repeat it": or, why I study the history of computing. IEEE Ann. Hist. Comput. **18**(2), 54–62 (1996)
2. Lee, J.: History of computing in education: an overview. In: Impagliazzo, J., Lee, J. (eds.) History of Computing in Education: TC3/TC9 Conference on the History of Computing in Education, pp. 1–16. Kluwer, New York (2004)
3. Sammet, J.: General AFIPS history of computing activities. Ann. Hist. Comput. **1**(1), 6–8 (1979)
4. Lee, J.: Pioneer Day, 1982. Ann. Hist. Comput. **6**(1), 7–14 (1984)
5. Lee, J.: Well behaved women rarely make history. SIGCSE Bull. **34**(2), 14–15 (2002)
6. Impagliazzo, J.: My fascination with computing history. In: Tatnall, A. (ed.) Reflections on the History of Computing. IAICT, vol. 387, pp. 385–395. Springer, Heidelberg (2012). https://doi.org/10.1007/978-3-642-33899-1_22
7. Impagliazzo, J., Campbell-Kelly, M., Davies, G., Lee, J., Williams, M.: History in the computing curriculum: the IFIP TC 3 (education committee) and TC 9 (relationship between computers and society committee) joint task group. IEEE Ann. Hist. Comput. **21**(1), 4–16 (1999)
8. Augarten, S.: Bit by Bit: An Illustrated History of Computers. Ticknor and Fields, New York (1984)
9. Campbell-Kelly, M., Aspray, W.: Computer: A History of the Information Machine. Basic Books, New York (1996)
10. Freiberger, P.: Fire in the Valley: The Making of the Personal Computer. McGraw-Hill, Berkeley (1984)
11. Levy, S.: Hackers: Heroes of the Computer Revolution. Doubleday, Garden City, NY (1984)
12. Pugh, E.: Building IBM: Shaping an Industry and Its Technology. MIT Press, Cambridge (1995)
13. Williams, M.: A History of Computing Technology. IEEE Press (1997)
14. Stern, N.: From ENIAC to UNIVAC: An Appraisal of the Eckert-Mauchly Computers. Digital Press (1981)
15. Impagliazzo, J., Lee, J.: Using computing history to enhance teaching. In: Impagliazzo, J., Lee, J. (eds.) History of Computing in Education: TC3/TC9 Conference on the History of Computing in Education, pp. 165–175. Kluwer, New York (2004)
16. Szabó, M.: László Kalmár and the first university-level programming and computer science training in Hungary. In: Leslie, C., Schmitt, M. (eds.) HC 2018. IAICT, vol. 549, pp. 40–68. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-29160-0_3
17. Sundblad, Y.: UTOPIA: participatory design from Scandinavia to the world. In: Impagliazzo, J., Lundin, P., Wangler, B. (eds.) HiNC. IAICT, vol. 350, pp. 176–186. Springer, Heidelberg (2011). https://doi.org/10.1007/978-3-642-23315-9_20
18. Lundin, P.: Designing democracy: the UTOPIA-project and the role of the Nordic labor movement in technological change during the 1970s and 1980s. In: Impagliazzo, J., Lundin, P., Wangler, B. (eds.) HiNC. IAICT, vol. 350, pp. 187–195. Springer, Heidelberg (2011). https://doi.org/10.1007/978-3-642-23315-9_21

19. Sikora, M.: Cooperating with Moscow, stealing in California: Poland's legal and illicit acquisition of microelectronics knowhow from 1960 to 1990. In: Leslie, C., Schmitt, M. (eds.) HC 2018. IAICT, vol. 549, pp. 165–195. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-29160-0_10
20. Leslie, C.: From CoCom to dot-com: technological determinisms in computing blockades, 1949 to 1994. In: Leslie, C., Schmitt, M. (eds.) HC 2018. IAICT, vol. 549, pp. 196–225. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-29160-0_11
21. Jiménez, T.L., Morell, M.F.G., Negrin, A.E.: Cuban experiences on computing and education. In: Impagliazzo, J. (ed.) History of Computing and Education 3 (HCE3). IAICT, vol. 269, pp. 55–77. Springer, New York (2008). https://doi.org/10.1007/978-0-387-09657-5_4
22. Toro, F.: Experiences as a student in Chile with only pre-computer technologies. In: Tatnall, A., Davey, B. (eds.) Reflections on the History of Computers in Education. IAICT, vol. 424, pp. 347–364. Springer, Heidelberg (2014). https://doi.org/10.1007/978-3-642-55119-2_24
23. Lundh, Y.: Development of Internet technology and Norwegian participation. In: Impagliazzo, J., Lundin, P., Wangler, B. (eds.) HiNC. IAICT, vol. 350, pp. 287–296. Springer, Heidelberg (2011). https://doi.org/10.1007/978-3-642-23315-9_32
24. Spilling, P.: The Internet development process: observations and reflections. In: Impagliazzo, J., Lundin, P., Wangler, B. (eds.) HiNC. IAICT, vol. 350, pp. 297–304. Springer, Heidelberg (2011). https://doi.org/10.1007/978-3-642-23315-9_33
25. Fet, Y.: From the history of Russian computer science. In: Tatnall, A. (ed.) Reflections on the History of Computing, IFIP AICT, vol. 387, pp. 265–88 (2012)
26. Dittmann, F.: Technology vs. political conflict – how networks penetrate the iron curtain. In: Tatnall, A., Leslie, C. (eds.) HC 2016. IAICT, vol. 491, pp. 49–57. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-49463-0_3
27. Schmitt, M.: Socialist life of a U.S. Army computer in the GDR's financial sector. In: Leslie, C., Schmitt, M. (eds.) HC 2018. IAICT, vol. 549, pp. 139–164. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-29160-0_9
28. Paju, P.: A failure revisited: the first Finnish computer construction project. In: Bubenko, J., Impagliazzo, J., Sølvberg, A. (eds.) HiNC 2003. IAICT, vol. 174, pp. 79–94. Springer, New York (2005). https://doi.org/10.1007/0-387-24168-X_7
29. Carlsson, A.: On the politics of failure: perspectives on the "Mathematics Machine" in Sweden, 1945–1948. In: Bubenko, J., Impagliazzo, J., Sølvberg, A. (eds.) HiNC 2003. IAICT, vol. 174, pp. 95–110. Springer, New York (2005). https://doi.org/10.1007/0-387-24168-X_8
30. Kitova, O.V., Kitov, V.A.: Anatoly Kitov and Victor Glushkov: pioneers of Russian digital economy and informatics. In: Leslie, C., Schmitt, M. (eds.) HC 2018. IAICT, vol. 549, pp. 99–117. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-29160-0_6
31. Kitov, V.A.: On the history of Gosplan, the main computer center of the state planning committee of the USSR. In: Leslie, C., Schmitt, M. (eds.) HC 2018. IAICT, vol. 549, pp. 118–126. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-29160-0_7
32. Gerovitch, S.: InterNyet: why the Soviet Union did not build a nationwide computer network. Hist. Technol. **24**(4), 335–350 (2008)
33. Tatarchenko, K.: "Lions – Marchuk": the Soviet-French cooperation in computing. In: Impagliazzo, J., Proydakov, E. (eds.) SoRuCom. IAICT, vol. 357, pp. 235–242. Springer, Heidelberg (2011). https://doi.org/10.1007/978-3-642-22816-2_28
34. Baehrs, A.A.: The MRAMOR workstation. In: Impagliazzo, J., Proydakov, E. (eds.) SoRuCom. IAICT, vol. 357, pp. 134–141. Springer, Heidelberg (2011). https://doi.org/10.1007/978-3-642-22816-2_17
35. Tatnall, A., Blyth, T., Johnson, R.: (eds.): Making the History of Computing Relevant. IAICT, vol. 416 (2013). https://doi.org/10.1007/978-3-642-41650-7

36. Lundin, P.: From computing machines to IT. In: Impagliazzo, J., Järvi, T., Paju, Petri (eds.) HiNC. IAICT, vol. 303, pp. 65–73. Springer, Heidelberg (2009). https://doi.org/10.1007/978-3-642-03757-3_7
37. Opmane, I., Balodis, R.: ICT history study as corporate philanthropy in Latvia. In: Leslie, C., Schmitt, M. (eds.) HC 2018. IAICT, vol. 549, pp. 304–316. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-29160-0_16
38. Ainsworth, A.B., Avram, C., Sheard, J.: The Monash University museum of computing history: ten years on. In: Tatnall, A. (ed.) HC 2010. IAICT, vol. 325, pp. 216–227. Springer, Heidelberg (2010). https://doi.org/10.1007/978-3-642-15199-6_22
39. Smolevitskaya, M.: The engineering heritage of Bashir Rameev at the Polytechnic Museum: honoring the 100th anniversary of his birth. In: Leslie, C., Schmitt, M. (eds.) HC 2018. IAICT, vol. 549, pp. 317–341. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-29160-0_17
40. Polak, Y.: The history of computers and computing in virtual museums. In: Impagliazzo, J., Proydakov, E. (eds.) SoRuCom. IAICT, vol. 357, pp. 201–207. Springer, Heidelberg (2011). https://doi.org/10.1007/978-3-642-22816-2_24
41. Kitov, V.A., Proydakov, E.M.: Twentieth anniversary of the Russian Virtual Museum of computing and information technology history. In: Leslie, C., Schmitt, M. (eds.) HC 2018. IAICT, vol. 549, pp. 295–303. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-29160-0_15
42. Kasyanov, V.N.: An open adaptive virtual museum of informatics history in Siberia. In: Impagliazzo, J., Proydakov, E. (eds.) SoRuCom. IAICT, vol. 357, pp. 194–200. Springer, Heidelberg (2011). https://doi.org/10.1007/978-3-642-22816-2_23
43. SCI Journal: IFIP Advances in Information and Communication Technology impact factor & key scientometrics. https://www.scijournal.org/impact-factor-of-ifip-advances-in-information-communication-tech.shtml. Accessed 1 Aug 2023
44. Cignoni, G.A., Gadducci, F.: Using old computers for teaching computer science. In: Tatnall, A., Blyth, T., Johnson, R. (eds.) HC 2013. IAICT, vol. 416, pp. 121–131. Springer, Heidelberg (2013). https://doi.org/10.1007/978-3-642-41650-7_11
45. Bodrato, S., Caruso, F., Cignoni, G.A.: Discovering Eastern Europe PCs by hacking them … today. In: Leslie, C., Schmitt, M. (eds.) HC 2018. IAICT, vol. 549, pp. 279–294. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-29160-0_14
46. Leslie, C.: Critical reading with STS: interdisciplinary inspiration for the science classroom. In: Borst, A., DiYanni, R. (eds.) Critical Reading Across the Curriculum, Volume 2: Social and Natural Sciences. Wiley, Hoboken (2020)
47. Anderberg, L.: STEM undergraduates and archival instruction: a case study at NYU Polytechnic School of Engineering. Am. Archivist **78**(2), 548–66 (2015)
48. Jankowski, A.: Digitized archival primary sources in STEM: a selected webliography. Issues Sci. Technol. Librariansh. (2017). https://digitalrepository.unm.edu/ulls_fsp/120/. Accessed 1 Aug 2023
49. Kreps, D., et al. (eds.): This Changes Everything – ICT and Climate Change: What Can We Do? 13th IFIP TC 9 International Conference on Human Choice and Computers. Springer, New York (2018). https://doi.org/10.1007/978-3-319-99605-9
50. Ruddiman, W.F., et al.: Defining the epoch we live in. Science **348**(6230), 38–39 (2015)
51. Chakrabarty, D.: The Climate of History in a Planetary Age. University of Chicago Press, Chicago (2021)
52. Ghosh, A.: The Great Derangement: Climate Change and the Unthinkable. University of Chicago Press, Chicago (2016)
53. Starosielski, N.: The Undersea Network. Duke University Press, London (2015)
54. Perez, C.S.: Thinking (and feeling) with Anthropocene (Pacific) islands. Dialog. Hum. Geogr. **11**(3), 429–433 (2021)

55. Leslie, C.: On diversity, equity, and inclusion in computing: finding allies in overrepresented populations. In: Strous, L., Johnson, R., Grier, D.A., Swade, D. (eds.) Unimagined Futures – ICT Opportunities and Challenges. IAICT, vol. 555, pp. 142–161. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-64246-4_12
56. Kleiman, K.: Proving Ground: The Untold Story of the Six Women Who Programmed the World's First Modern Computer. Grand Central Publishing, New York (2022)
57. Lindencrona, E.: Where were the women? In: Bubenko, J., Impagliazzo, J., Sølvberg, A. (eds.) HiNC 2003. IFIP, vol. 174, pp. 405–411. Springer, New York (2005). https://doi.org/10.1007/0-387-24168-X_36