Teaching Machines: The History of Personalized Learning, 2021. By Audrey Watters. MIT Press. 328 pages. ISBN: 9780262045698

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Introduction

Teaching Machines by journalist Audrey Watters blends the historical and political events of 1920-1960s in the United States and the changes in the K-12 school system, chronicling the rapid development of educational technology markets to show the inception and evolution of teaching machines. The author expresses her indignance towards Silicon Valley entrepreneurs who continue launching educational businesses, under the assumption that their "new" technological breakthrough will change the "stagnant" field of education technology. This book explicates how the "new idea" of personalized learning offered by current educational technology companies and industries dates back a century to the 1920s.

Pressey's Automatic Teacher

Watters begins her account of the history of teaching machines by describing the work of Sidney Pressey who, in the early 1920s and in cooperation with his wife Luella Cole, created almost 50 standardized tests, which were sold in the millions to schools as a new type of 'standardized' assessment. In part and influenced by this success, Pressey sought to build an Automatic Teacher, a machine that would provide learners with the answers instantaneously and free teachers from time consuming standardized test evaluation, an issue he had created previously.

After numerous unsuccessful attempts approaching manufacturers of typewriters, cash registers, scientific equipment, and publishers, as chronicled by Watters in 1929, Pressey teams up with a thriving W. M. Welch Manufacturing founded by a former superintendent. The letters and memoranda offered by Watters allows readers to witness the miscommunication between the manufacturing company and the scholar as they both worked toward refining and commercializing the Automatic Teacher. Pressey was so driven by the project that the lack of progress negatively impacted his mental health, and he had to spend months recovering in a mental hospital. Although it was hard for Pressey to give up the

realization of the Automatic Teacher, eventually the work on the machine ended as did his marriage to Luella Cole, a prominent scholar who wrote several remarkable books on education.

The Creation of Teaching Machines: B. F. Skinner

Another prominent behavioural psychologist at the time, and indeed the focus of the book, is Burrhus Fredric Skinner who also became enthralled with the idea of constructing a teaching machine. Working at Harvard, Skinner started a new project aimed at building a teaching machine that would create a more personalized learning approach. As with many of Skinner's early behaviouristic experiments, this innovative idea was mostly oriented toward training students through positive reinforcement, something that built on his early and very famous work with training pigeons during WWII (Skinner, 1962) to guide missiles (though none ever did).

Almost a year after B. F. Skinner secured grants, hired a team of young scholars, and signed a contract with IBM for the development of a teaching machine, the Soviet Union launched Sputnik, the first satellite to be successfully launched into space, which escalated the Cold War between the Soviets and the Americans. American politicians and scholars found a connection between the launch of the artificial satellite and the science-oriented Soviet system of education, and viewed it as a potential threat to the supremacy of the American educational system for years to come. Skinner's teaching machine seemed to be the right project for that specific place and time.

Early in the teaching machine project, Skinner and his lab collaborated with IBM, focused on the creation of an arithmetical device that was an early version of a computer. Skinner's graduate student – Susan Meyer (Markle) – wrote what would be an incredibly important arithmetic program for IBM, which according to Markle (1964), would adjust lessons to learners' needs and challenge them to move forward. When the tension between Skinner and IBM escalated, Markle's rights, title, and interests were signed over to B. F. Skinner, although she had contributed to the development of early teaching machines.

When the collaboration between B. F. Skinner and IBM did not work out, Skinner looked for other potential business partners. Rheem Manufacturing Company was eventually contracted by Skinner to work on his teaching machine, that Skinner preferred to be named "Didak" or "Autodidak" in reference to the Greek word 'education' or 'self-education', which he knew would not be favored by teachers. Eventually, Rheem contractually agreed to officially name the device "Didak".

The Roanoke Experiment

While B. F. Skinner tried to take every opportunity to commercialize Didak, other researchers also worked to develop and implement programmed instruction. One of the most significant contributions in the field of teaching machines was made by Allen Calvin, a psychology professor at Hollins College, Virginia. Calvin received a generous grant from the Carnegie Foundation, of what would amount to over a half million US dollars by today's standards. These funds were used to conduct

an experiment at Roanoke Public Schools; schools that were racially segregated at that time. The study focused on the progress of eighth grade students who were taught ninth grade algebra via programmed instruction. The results showed that the learners were able to cover an entire year of ninth grade content in one semester. Since all the instruction and assessment completed by the teaching machines proved to be successful in "The Roanoke Experiment", it was agreed to expand the study. The subsequent study included 11 teachers and 900 students. However, due to the cost of the experiment, this time students used programmed textbooks. The programmed textbooks, as the machines, ensured that the learners acquired mathematical concepts at their own pace.

According to the Roanoke district superintendent, Edward Rushton, in addition to the favorable outcome of the experiment, teachers who participated in the study claimed that programmed instruction led to reconsidering their pedagogical practices. This second success created a chain reaction. Additional funds and a million-dollar grant from the Encyclopedia Britannica Films led to the hiring 700 staff. Nevertheless, only three months after the relocation to Palo Alto, the work on the project stopped due to disputes between the business-oriented Encyclopedia Britannica Films representatives and the academically oriented Hollins College scholars.

Teaching Machines: Technocratic Approaches

There were examples of successful collaboration between encyclopedia publishers and researchers. Teaching Machines Inc. (TMI) cofounded in 1959 by Lloyd Homme, who earlier worked under the supervision of B. F. Skinner, and James Evans, teamed up with one of the largest encyclopedia publishers – Grolier. The door-to-door sales approach was a familiar marketing tactic for educational technologies at the time, as encyclopedias were most often sold this way and there was an ongoing distrust of the public education system in the U.S. Unlike full sets of encyclopedias, the Min/Max machines required much less investment, and it became clear that door-to-door sales made TMI's Min/Max successful. As its name suggests, Min/Max machines offered maximum learning in a minimum amount of time. The questions were constructed in a way that they gradually grew more complex as a learner proceeded through the program. Although the affordable machine promised that students would learn at their own pace, students could easily get bored by working on numerous, repetitive, and relatively simple tasks before they faced more challenging questions. Lloyd Homme was not the only person who, after working with B. F. Skinner, created a commercially successful teaching machine.

Ben Wyckoff, B.F. Skinner's former student, left his behaviouristic views behind and created a more sophisticated machine that was considered an early prototype of a computer, which unlike the Min/Max machine, did not use paper. Grolier was interested in the program of the machine rather than commercializing a bulky and pricey device. Wyckoff's film-tutor focused on teaching students how to read in a more engaging way as opposed to the simple "Question and Answer" format of teaching machines. A. A. Lumsdaine (1960) compared it to Norman Crowder's AutoTutor. Crowder's series of self-instructional manuals, TutorTexts, were adaptive to learners' needs. Depending on the nature of the

error made by the student in reading – a miscalculation or misunderstanding of the concept – the teaching machine would provide a suggestion about what page in the book to revisit to help correct the misunderstanding. From earlier machines that provided learners with the answers, this system focused on finding out *why* a learner made the mistake and what *approaches* needed to be utilized to master the task. Crowder seemed to have outgrown the ideas he worked on in Skinner's lab in 1954.

Watters claims that although Crowder called his version of programmed instruction "intrinsic", it was often described as "branching" (p. 141). In Skinner's model, students repeated the incorrect questions until getting them correct. Crowder's branching allowed more incorrect answers and provided alternative pathways, or branches, to arriving at the correct answer. Put another way, if Skinner's "linear" model required all students to go through the same set of questions, Crowder ensured that each student had alternate paths on the way to content acquisition. In his book entitled "Teaching Machine (and Learning Theory) Crisis", Pressey (1963) foresaw the crisis of the teaching machine movement, which he argued would fail due to the flaws of the behavioristic approach. The shift towards progressivism and a student-oriented approach led to the creation of more innovative programs and, in the 1980s, would be realized by more technologically complex descendants of the early teaching machines – computers.

Conclusion

At first sight there is an impression that every event described in the book revolves around B. F. Skinner. The irony of a one-man show is understandable as readers might not be familiar with the contribution of other scholars in the field of teaching machines and personalized education. In her blogpost "(Searching for) Norman A. Crowder and the AutoTutor" from 2018, Watters wrote that she was looking for Crowder's letter and papers. Apparently, researchers who tried to improve the field of personalized education were shadowed by their former employer – B. F. Skinner. Another topic that is omitted in the conversation is teachers. Although the book mentions that several scholars and journalists have viewed teachers as engineers and curators of the process of education, there have not been attempts made to train instructors for such purposes. For quite some time, researchers and technology companies have been dreaming about a utopia where there would be no practical use of teachers. This dream has not been reached despite the massive investments in technologies for education. Despite the promises of new and different technologies, much like teaching machines of the past, they have not offered solutions to the crisis in public education in the USA. As the outbreak of the global COVID-19 pandemic and social distancing made clear, we still need skilled and stress-resistant *human* teachers who can support and empathize with students.

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