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Philipps Universität Marburg

Instructional Devices

Teaching Machines, Serious Games and Subject Technologies[1]

Rolf F. Nohr

Abstract

Under the gamification heading, we are currently discussing a collection of control policies that—depending on the perspective—are either considered omnipotent opportunities to control behaviour and create motivation or, on the other hand, dystopian and inhuman 'subliminal' disciplines aimed at breaking the subject in. Regardless of one's own position: the discussion of a gamified rationality cannot abstain from looking at the discursive prerequisites that led to the gamification debate of the 2010s. To do so, the following aims to (briefly) trace gamification back to two preceding historic developments: to a specific from of ('playful') learning and the consequences related to control policies that arise from this 'expanded definition of learning'.[2] The digitalisation of classrooms and gamified educational offers developed and applied today are not without historic precedent. In the past, tremendous efforts (and investments) were made to equip classrooms with the latest media technology.

Keywords

teaching machines, dystopian, subliminal disciplines, gamified education, Skinner, computer-based education, RAND corporation

1 This article is a revised and condensed version of Chapter 8.2 in: Nohr 2019.

2 It is not surprising that the 'prerequisites' of gamification go back a long way. Fuchs (2016: 13), for example, demonstrates that the Century of Play has been announced at least twice. He quotes Daniel Bernoulli, for example: "There is no better way for this century to go down in the history books than under the name: the journal of free spirits and the century of play."

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> "For every old blackboard there are now hundreds of new electronic computers" (Dwight D. Eisenhower).[3]

Teaching Machines

The beginning of the 1950s saw a (short) boom in teaching machines (TM) in the USA. For a short period of time, this project, which focused on machine-based learning that was initially supported by mechanical devices, attracted considerable attention. TMs were widely integrated into schools, were a subject of detailed discussion in the field of science and, last but not least, received positive feedback in public perception.

Fig. 1: "Different teaching machines: Rheem Didak 101 Pre-Verbal Machine (approx. 1960)" (source: Fry 1963: 27.

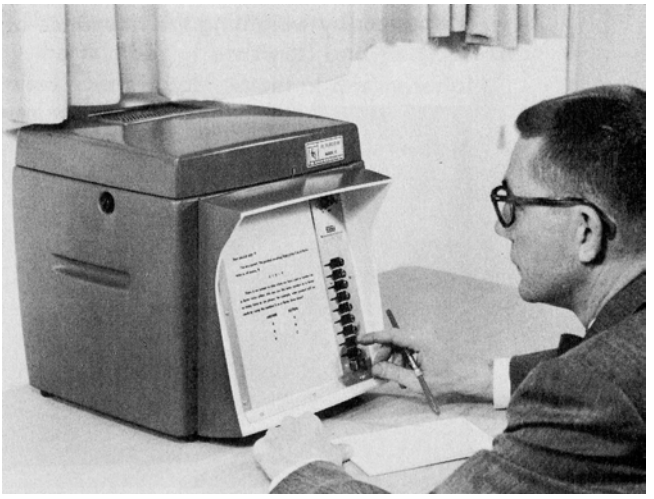
Popular Mechanics magazine published a report on TMs titled "Will Robots Teach Your Children?"—and could hardly have been more wrong. The subheading goes on to—more correctly— promise "a revolution in mass education".[4] For at this time, TMs were not a project that organised schooling by means of an automated,

3 Cited in Norberg 2005: 267.

4 *Popular Mechanics*, October 1961, p. 152-157.

third instance but rather an approach that initially aimed to help schools and universities overcome their crisis (more on this below), pragmatically and from a scientific and educational perspective by means of autonomous and self-motivated learning methods. A contemporary 'fantasy' of 'tomorrow's education' reads as follows: Pupils spend approx. 40% of their lessons in front of the TM, 40% of their time in lecture-styled activities and a mere 20% in small groups (that require intensive support). According to this scenario, the time spent in primary and secondary school would still be one to two years longer, despite an increase in effectiveness—simply because the increase in effectiveness and rationalisation of education allow schools to advance specialisation and prevent retraining at a later date. However, it would be possible to retrain students to other (industrial) occupations in three to six weeks (Czemper/Boswau 1965: 12f). 'Techno-euphoric' utopias like these were fed by a rather naive faith in progress (which should not necessarily be attributed to the 1950s alone)—as well as by quite real and concrete political and scientific positing.

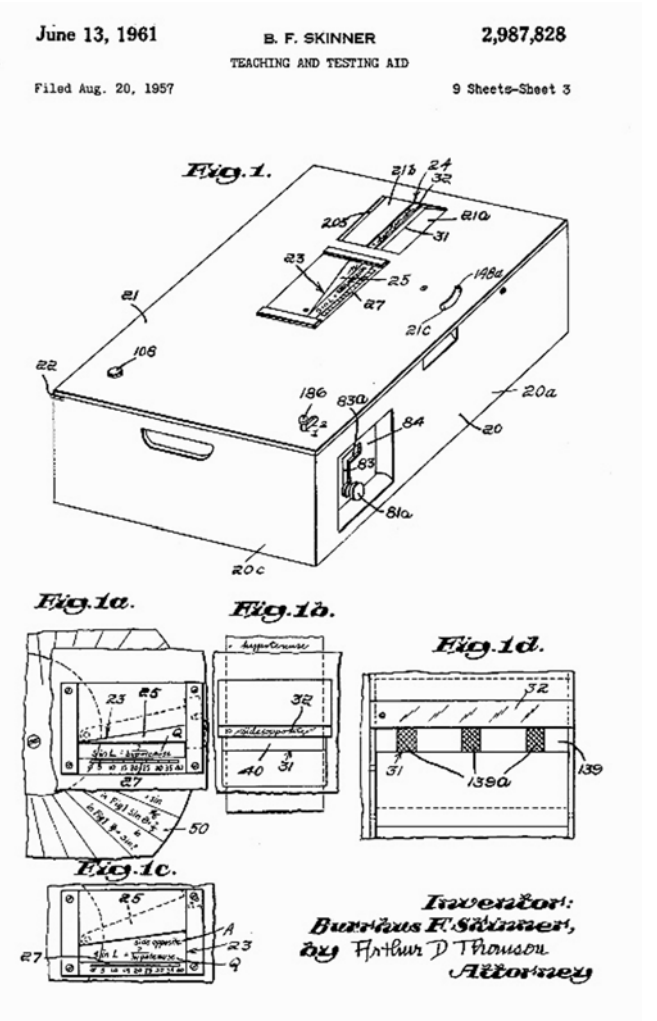
Fig. 2: "Norman Crowder using the Mark II Auto Tutor teaching machine (approx. 1962)" (source: Fry 1963: 31.



As we can see, TMs are discussed less as learning devices and more as a paradigmatic change in educational concepts, which is why this discussion focuses on the learning programme itself as opposed to the technology. And this learning programme basically uses the methods of multiple-choice tests. Pupils are seated at a mechanical device (later at a computer) (Fig. 1-3) and tackle the subject matter themselves in a staggered question and answer process (Fig. 4). The device presents prefabricated 'knowledge segments', followed by a set of questions that the student has to answer. If the answer is correct, the programme proceeds to the next learning step; if the answer is wrong, the programme repeats its presen-

tation of the required knowledge in iterations of varying complexity. Students progress at their own individual speed, determined by their own 'knowledge processing' skills. The iterations—which can potentially be executed endlessly—aim to ensure that learning progresses in any event. As a result, machine and subject-based TMs focus on the individuality of learning—whilst at the same time positing the redundancy of teachers.

Fig. 3: "Diagram of a teaching machine according to Skinner"; (source: Fuchs 1969: 115).



TMs were developed for pre-schoolers as well as for adults, for use in mathematics and language lessons as well as for training staff at nuclear missile silos. TMs promise the 'algorithmability' of the learning process as well as the redundancy of

the traditional teaching format, teaching personalities and collaborative learning. In the specific versions of the 1950s and 1960s, TMs are pioneers of computer-based information and educational programmes, just as they prepare the way for the technical tradition of language laboratories and educational programmes on the radio and TV.

Fig. 4: Excerpt of a teaching machine programme: "Table 2 shows a brief 4-item excerpt from a program in electrical fundamentals. The items would normally be seen only one at a time. Assume the student responds correctly to Item 62 with the word 'transformer,' on the basis of what he has learned in preceding sequences. If he does not, the correct answer will, of course, be provided after he has tried to answer the item. Cues for the response 'coils' for Item 63 are provided by the statement just previously read in Item 62; similarly, the terms 'primary' and 'secondary' required in Item 64 will have just been used in Item 63, and so on" (source: Lumsdaine 1959: 174).

TABLE 2.—PROMPTING BY CUES FROM PRECEDING ITEMS IN A TEACHING MACHINE PROGRAM

62. A.....?....., used to control voltages, consists of two coils of wire, wound on a core.
63. Input and output voltages of a transformer are governed by the number of turns of wire in the primary and secondary.....?.....
64. The ratio of the number of turns in the .....?..... and in the .....?.....coils determines the ratio of input and output voltages.

From an epistemological point of view, TMs are centrally connected to behaviourism and Burrhus Frederic Skinner's theory of learning. In his paradigmatic 1958 essay, Skinner refers to two key developments that he says should by necessity advance the establishment of automated learning. On the one hand are the changing responsibilities of education (in schools) in light of increasing population figures. The TM euphoria was not least caused by the blatant lack of teachers (cf. Vogt 1966: 24; Fry 1963: vii)[5] Skinner too argues that the introduction of TMs should be seen as a means of preventing regressions compared to the

5 Skinner provides a variation of this (1958: 976): "Will machines replace teachers? On the contrary, they are capital equipment to be used by teachers to save time and labor. In assigning certain mechanizable functions to machines, the teacher emerges in his proper role as an indispensable human being. He may teach more students than heretofore—this is probably inevitable if the world-wide demand for education is to be satisfied—but he will do so in fewer hours and with fewer burdensome chores. In return for his greater productivity, he can ask society to improve his economic condition".

achieved quality of education in light of the crisis in the education sector.[6] On the other, the necessity of introducing TMs is also motivated by the progress in media technology: Skinner also mentions (1958: 969) the development of audio-visual media as a (positive) challenge to adapt educational situations to current technical possibilities.

In his concrete works on TMs, Skinner refers to studies and considerations that psychologist Sidney L. Pressey conducted as early as the end of the 1920s (1958: 969). Pressey presented his own system of programmed learning (initially without further resonance).[7] Starting from his theory of learning (which basically comprised three rules of learning) and closely following Edward L. Thorndike's[8] approaches on 'instrumental conditioning', Pressey developed a simple test device that required students to answer prefabricated questions by pressing buttons and that provided immediate feedback on the fittingness of their input (Fig. 5-6). In 1926, Pressey summarised the results of his work at Ohio State University as follows:

"The somewhat astounding way in which the functioning of the apparatus seems to fit in with the so-called 'laws of learning' deserves mention in this connection. The 'law of recency' operates to establish the correct answer in the mind of the subject, since it is always the *last* answer which is the right one. The 'law of frequency' also cooperates; by chance, the right response tends to be made most often, since it is the *only* response by which the subject can go on to the next question. Further, with the addition of a simple attachment, the apparatus will present the subject with a piece of candy or other reward upon his making any given score: for which the experimenter may have set the device; that is, the 'law of effect' also can be made, automatically, to aid in the establishing of the right answer." (Pressey 1926, cited after Lumsdaine/Glaser (eds.) 1960: 37).

6 In light of the dramatic changes within the education sector, Skinner warns against the call for 'strict education' as in the end, this often means 'repressive education' (1958: 977): "The discipline of the birch rod may facilitate learning, but we must remember that it also breeds followers of dictators and revolutionists. In the light of our present knowledge a school system must be called a failure if it cannot induce students to learn except by threatening them for not learning. That this has always been the standard pattern simply emphasizes the importance of modern techniques. [...] Progressive education has been a temporizing measure which can now be effectively supplemented. Aversive practices can not only be replaced, they can be replaced with far more powerful techniques. The possibilities should be thoroughly explored if we are to build an educational system which will meet the present demand without sacrificing democratic principles".

7 The discussions on the extent to which Skinner was actually influenced by and/or 'adapted' these started immediately after publication of Skinner's text (cf. Benjamin 1988: 703f).

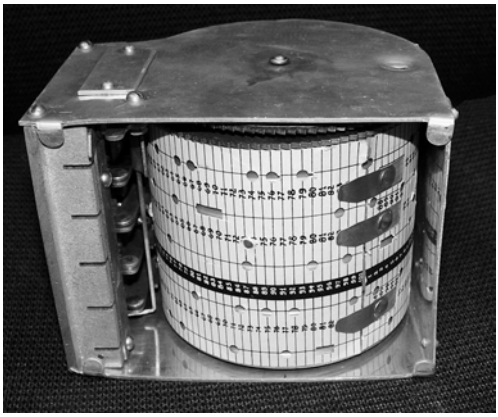
8 For more on Thorndike's influence on Pressey, cf. Niemiec/Walberg 1989: 265f.

In his interpretation of Pressey's work, Skinner subsumed that the apparatus of programmed learning would 'test' and 'evaluate' and would, at the same time, be able to trigger actual learning processes. These learning processes would also be characterised to a considerable extent by the individualisation of the learning process[9] and would therefore be able to cause an "industrial revolution in education" (Skinner 1958: 969). However, Skinner exceeds Pressey's work in this sense by redefining the learning process—namely in the context of a 'modification of emitted changes in behaviour' and less as conveying knowledge. In Skinner's eyes, this renders the actual machine secondary compared to the actual 'knowledge-changing programme' (cf. Niemiec/Walberg 1989: 266).

Fig. 5: Pressey Testing Machine (patented in 1928 / 1930), exterior view. (Image: Gomer Bolstrood, 7 September 2006; © Wikimedia Commons; source: [https://en.wikipedia.org/wiki/History_of_virtual_learning_environments#/media/File:Pressey_Testing_Machine_1.jpg]

9 Whereas the individualisation is (initially) seen as a one-to-one learning process (and not as a self-technique): "The kind of individual difference which arises simply because a student has missed part of an essential sequence (compare the child who has no 'mathematical ability' because he was out with the measles when fractions were first taken up) will simply be eliminated" (Skinner 1958: 976). TMs are only considered 'learning without assistance' (Fry 1963: 1) in individual cases.

Fig. 6: Interior view with answer punch card (image: Gomer Bolstrood, 7 September 2006; © Wikimedia Commons; source: [https://en.wikipedia.org/wiki/History_of_virtual_learning_environments#/media/File:Pressey_Testing_Machine_2.jpg]



The beginning of the TM boom is marked by the 'rediscovery' of Pressey's work and Skinner's own essay at the latest.[10] In 1962, American educational psychologist Robert Glaser (1962) introduced the term of 'instructional systems' in regard to TMs and programmed learning. In 1965, psychologist and educator Robert Gagné published his book *The Conditions of Learning*, which quickly became a great success, advanced to a paradigmatic work on teaching theory and sparked a broad occupation with instructional design. In 1961, Charles I. Foltz published his book *The World of Teaching Machines. Programmed Learning and Self-Instructional Devices*. The book is a fundamental work within the TM movement; however, it does assume a 'wait-and-see' attitude and tries not to be too euphoric when talking about the subject.[11] In the USA, Foltz developed a nomenclature that fittingly

10 Niemiec/Walberg (1989: 264f.) prove that the approaches of machine-supported learning can be traced back much further.

11 Outside of the USA, other national booms in TMs are hard to identify. The international conference titled *Programmierter Unterricht und Lehrmaschinen* [Programmed Lessons and Teaching Machines] held in Berlin in 1963 is one of few German publications (Bianchéir et. al (ed.) 1964) and can be seen as the debut of Federal German science to the discourse. However, this must at the same time be seen as its exit; although a series of more or less popular scientific publications did appear after the Berlin conference (Vogt 1966; Fuchs 1969), the specialist debate quickly ran dry (cf. Riederer 1964: 119f). One of the focal points in teaching machine development and information psychology in the Federal Republic of Germany was the Institute for

subsumes the direction of impact of this new learning technique: "self-instructional device" (1961: 13).[12]

Learning Concepts, Learning Markets

Besides the obvious compatibility with the principle of Taylorian thoughts on increasing effectiveness popular at the time (Niemiec/Walberg 1989: 264), the underlying learning concept (that was geared towards behaviourism[13]) is key to understanding the TM movement. In the discussion on TMs, the learning effect is usually understood within the meaning of 'operant conditioning'[14], characterised by an almost immediate, individualised feedback on learning success (or, to be more precise: the correctness of the answer) (Lumsdaine 1959: 164; Foltz 1961: 41). This is dominated by the behaviourism action theory, in which observable, empiric and unambiguous human (and animal) reactions are traced back to environmental stimuli. The (interior) structure of the studied object is initially of no interest, a demonstrable connection between input and output is key. In the concrete case of TMs, this input is a defined educational content combined with the size of the class, the age of the students and the duration of education (Zöller 1975: 99). Correspondingly, the output is the measurable learning result. From today's perspective, of course, concepts like this sound 'naive' and demonstrate too little complexity. It seems easy to criticise behaviourism portrayed in this manner. However, at this point it seems essential not to concentrate too much on a general methodological critique but instead to reflect on how this learning approach could be continued in specific learning techniques.

In the 1960s, this 'operant' conceptualisation of the learning process essentially gave rise to two schools of thought on programming the learning process by means of instructional devices: the Skinner school of thought and the Cowder school

Cybernetics, founded at the University of Teacher Education in Berlin [PH Berlin] on 28 August 1964 and headed by Helmar Frank. The institute considered itself the first institute at a German university to deal with cybernetic education (Lehnert 1969, 3).

12 The term 'programmed instruction' is also used, however, it avoids the emphasis on the self-technology of learning whilst indirectly evoking it: "Programed instruction is an empirical process of developing self-instructional materials that have been designed to achieve predictable, behaviourally-stated objectives" (Komoski 1964: 85).

13 Very few sources reflect on behaviourism as a paradigm. Instead, we repeatedly find explanations that are quite 'carefree' in their historicism of the employed theory of learning and unwaveringly trace it back to Socratic and Cartesian learning methods, for example (cf. Vogt 1966: 26; Foltz 1965: 15; Lumsdaine 1959: 164).

14 TMs designed for use in preschools and primary schools prove that, in individual cases, conditioning is actually meant in a Pavlovian sense. When the right answers are entered, these machines reward the amplification of learning by emitting sweets, jams and scents that have a positive connotation (cf. Foltz 1965: 75; see Fig.11).

of thought.[15] These two types of learning programming essentially differ in the different conceptualisation of the repetitive process. Both emphasise the 'effectiveness' of the repeated entry/prompt of units that are to be learned. Skinner's 'linear programme', however, focuses in more detail on minute questions, on answers phrased by the students themselves and on the learning progress advancing in tiny steps (very much in the spirit of the operant conditioning learning approach). In contrast, Cowder's 'branching programming' emphasises the explicit effect of 'mistakes', the aim of which are to lead the student into enhanced repetitive routines and simultaneously—by a more strongly branching algorithm architecture—aim to guarantee a finer ('intrinsic', Fry 1963: 5) adaptation to the student's individual level of knowledge. Based more strongly on Pressey's work, Cowder favoured a type of multiple-choice test that provided immediate feedback when programming TMs. This exposed him to criticism claiming that in the end, his method came awfully close to "test and quiz questions" (Deutsch 1964: 44). Interestingly enough, we can conduct Cowder's method at a pen-and-paper level. The result of this are 'scrambled textbooks'[16]—books that are not read in a linear manner but instead conclude each block of information with a multiple choice question, the answer to which determines which text unit is to be read next (and which in turn concludes with a question) (Fry 1963: 33f).[17] Ultimately, the Skinner school of thought prevailed: Skinner "[...] had produced more than a machine; he had developed an educational technology that promoted a new approach to teaching [...]. The boom in teaching machines was underway in the early 1960s, and most of the devices were based on Skinner's theory of learning" (Benjamin 1988: 709).

15 Cf. Fry 1963: 17 -34; Deutsch 1964: 42. Norman A. Cowder was the Vice President and Technical Director of the Educational Science Division of the U.S. Industries.

16 In deviation, Lumsdaine (1959: 170ff) also mentions Glaser/Homme/Evans (1959) as the first reference of the Socratic textbook.

17 Today, the concept of 'branching' textbooks lives on in the shape of (role-playing game-oriented) adventure books. We could possibly productively consider to what extent this type of 'branching narration as decisive action' marks the connection of simulation and serious games to the wider field of role-playing games– not least because certain book-based (fantasy) role-playing games could be viewed as such scrambled textbooks: Within role-playing games, the branching narration as decisive action consists of predefined quests in the handbook that the group can play in a non-linear manner.

Fig. 7: Teaching Machine according to Skinner: closed... (source: [https://commons.wikimedia.org/wiki/File%3ASkinner_teaching_machine_01.jpg]; Foto von Silly Rabbit—Own work, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=3806150)

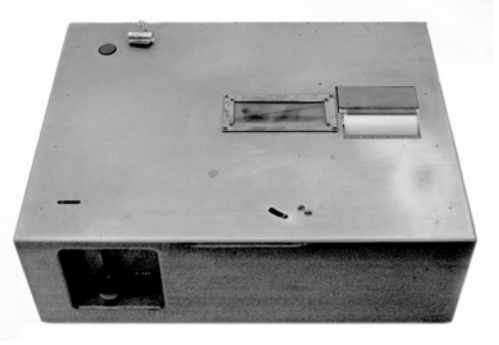


Fig. 8: ... and open. (source: https://commons.wikimedia.org/wiki/File%3ASkinner_teaching_machine_08.jpg]; Foto von Silly Rabbit—Own work, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=3806150)

By as early as the mid-1960s, a veritable market had developed: Foltz estimates that by around 1962, there were approximately 40 to 50 manufacturers of learning devices, with an additional 20 companies that produced corresponding textbooks and programmes. He (quite euphorically) calculated that the expected turnover for the next 10 years in this sector would amount to 100 million US$ (Foltz 1965: 53).[18] At the same time, a research funding programme was launched, which spent large sums provided by state-run institutions and private foundations (Carnegie Corporation, Ford Foundation, etc.) on conducting fundamental research at universities and institutes founded for this exact reason[19] (Czemper/Boswau 1965: 88).

Of course, opposition quickly formed against the extremely functional approaches of the TMs. Largely, this criticism claims that the underlying learning concept of behaviourism (as well as its inherent concept of man) does not understand learning as a 'subject effect' but instead, in the context of 'external governing', distorts it into the overly individual, manageable and controlling process of a 'learning object' that is no longer subject to its own will. Moreover, a debate erupted on the conflict between programmes and machines: We frequently encounter the sentence "The programme is everything, the learning machine nothing" (Deutsch: 1963: 39), which represents considerable criticism towards the "page-turning machines" (ibid). Using TMs in more complex learning situations, for example in industrial vocational training, would lead to students feeling 'patronised' by the machines, resulting in a tendency to disobey (Schirm 1964: 132).

Despite all criticism, the TM project expanded. IBM's TM project is worth mentioning as an advanced project of computer-based education (Fry 1963: 21; Niemiec/Walberg 1989): Within this project, the company developed the *IBM 650 Inquiry Station* (cf. Fig. 9) based on the IBM 650.

"IBM's Teaching Machines Project in the late 1950s was instrumental in developing programs such as one that taught binary arithmetic. The IBM 650, a high-speed digital computer, interfaced with a typewriter, was used as a teaching machine. This configuration was known as the 'IBM 650 Inquiry Station'. The IBM Inquiry Station is a typewriter and a console which is capable of transmitting typed information to the computer and receiving information from the computer. The student sits at the Inquiry Station. The program of

18 The relatively high amount can be explained by the cost-intensive process of manufacturing learning programmes: Foltz (1961: 47) states that the costs of the 'first programme of a trimester' (with 3,000 to 4,000 programme steps, the development of which he sets at 1,500 manpower hours) amount to 175,000 dollars.

19 One of the earliest (civil) research institutes appears to be the *Coordinated Science Laboratory*, founded at the University of Illinois in 1960. Headed by Donald L. Blitzer and Peter G. Braunfeld, this research project tackled instructional programmes. They developed a device for individual lessons: PLATO I (= Programmed Logic for Automatic Teaching Operations) (Belch 1973: 336f; Czemper/Boswau 1965: 50-63; Molnar 1997: 3f; ibid. 1990: 82).

instructions in the computer presents the problem to the student by way of the typewriter. The student, in turn, types his answers, which is transmitted to the computer for checking. IBM also developed a program called COURSEWRITER, the first computer language devoted to CAI programming".[20]

Fig. 9: IBM 650 RAMAC Inquiry Station (1961) (source: [http://sysrun.haifa.il.ibm.com/ibm/history/exhibits/650/650_ph16.html]; last accessed on 1 April 2019)

Examples like these illustrate how much the 'educational' concept of TMs broadened on the one hand, and how it followed the discourse on computerisation on the other—and how we can trace a diffusion in popular cultures from that point on. As the ambition of the parties involved increasingly shifted towards a media[21] and computer-based interpretation of teaching methodology during the second phase of the (short) TM 'boom', there was a rise in cooperations between universities and hardware manufacturers within the computer industry that were grouped under the umbrella term 'computer-assisted instruction' (CAI) (cf. Benjamin 1988: 710) as well as programmes initiated by the government, such as the US Office of Education's *Center for Programmed Instruction* (Eigen 1964: 57).[22] In this context, the Minnesota Educational Computing Consortium (MECC) is worth a mention. In cooperation with the *Total Information for Education System* (TIES) founded by Dale LeFrenz and others in 1968, the MECC established a computer network that

20 A hypertext history of instructional design. The 1950s: Programmed Instruction and Task Analysis (http://faculty.coe.uh.edu/smcneil/cuin6373/idhistory/ibm.html).

21 In this context, this primarily means slide and/or film-supported concepts that act as a 'second generation' that is intended to help TMs prevail (cf. Lumsdaine/May 1959).

22 Molnar (1990) and Niemiec/Walberg (1989) provide a compact overview of this.

used modems to connect (suburban) schools in the greater Minneapolis area to mainframe computers and used this infrastructure to provide learning software and automated learning assist systems to numerous school children for decades. One of the most 'successful' and renowned of MECC's learning programmes is *The Oregon Trail* from 1972, a simulation of the development of the West in the 1840s—for many Americans one of the first and most sustainable contacts with computer games—and a classic of video gaming history to this day.[23]

Think Tanks

The interest in the development of TMs shown by think tanks and the military-industrial complex is almost more interesting than the funding programmes provided by the government and private sector (cf. Lumsdaine 1959; Niemiec/Walberg 1989: 267ff). It is hardly surprising that this mainly relates to the operational 'appropriation' of machine learning techniques as a possibility of improving training, development and specialisation—as is clearly stated in a CIA policy document on TMs:

"For mass education is no longer a luxury from the standpoint of the society, the nation. At a time when its survival may depend upon the skill of some radar technician standing his lonely watch over complex electronic equipment on the DEW[24] line, when the tenfold increase since World War II in the intricacy of the armed forces' equipment requires that a draftee spend half his enlistment time learning his job, when the diverse branches of science have become so sophisticated that it takes an interdisciplinary specialist to communicate among them, it is not strange that the nation is examining with cautious hope a new philosophy of instruction that promises to teach men better in a shorter time. The new philosophy reassigns the main burden of responsibility for the student's learning to the teacher. If a student has trouble it is no longer quick to conclude that he is probably lazy or isn't paying attention or has poor aptitude for the subject; it assumes, rather, that there may be something wrong with the instruction" (Fulcher 1962: A6).

As early as 1955, the Air Research and Development Command developed automatic multiple-choice systems to train US Air Force military personnel (Fry 1963: 26). One of the main actors in the development of these systems was the

23 Cf. the online exhibition on TIES, MECC and the *Oregon Trail* at The Strong Museum of Play: [https://artsandculture.google.com/exhibit/TAICA30JZQm2Kw]; last access on 4 July 2018.

24 The Distant Early Warning Line (DEW Line) was a chain of radar stations located along the US and Canadian Arctic, which was part of the American early warning system until the end of the 1950s.

System Development Corporation (SDC), which arose from the RAND Corporation.[25] In 1958, the SDC launched the Education Research and Development Project, which dealt with questions on automated learning. To do so, the SDC established the *Computer-Based Laboratory for Automated School Systems* (CLASS), in which students from surrounding schools were tested using programmed learning technologies (Baum 1981: 84). The CLASS project was subordinate to the SCD's System Simulation Research Laboratory (SSRL) (Molnar 1990: 810). At SDC, this SSRL focussed on projects as diverse as, for example, the development of flight monitoring devices, content analysis and classification of text—as well as on instructional devices and man-machine-interface projects with an emphasis on programmed and machine-supported learning.[26]

From a relatively early stage on, various research projects showed that the automation of learning processes was not only (functionally) geared towards educational situations but (more discursively) towards a 'new' type of institutional control by means of 'data management'. The SDC, for example, illustrates that its interest exceeded automating lessons themselves and was aimed at introducing comprehensive 'administrative automations' for the entire school system. A general, computer-based organisation of the school system in toto, on the other hand, was a project pursued by others besides the SDC (Czemper/Boswau 1965: 74). It appears that one focal point of fundamental research in the environment of self-instructional devices, TMs and automated learning was also of a military-economic nature (Foltz 1961: 11).[27]

25 In the mid-1960s, the Air Force commissioned the RAND Corporation with developing a training programme for its entire radar-based air space monitoring. To develop this programme, RAND employed a staff of up to 500 people in various departments until 1957. The development itself led to a whole series of spin-off companies, among them the System Development Corporation, responsible for developing the necessary computer software as well as the decision-making programmes and training scenarios, the automated learning environment and the routine tests for the operators of this central, computer-based decision-making system (Baum 1981, 31pp.).

26 Cf. Czemper/Boswau 1965: 63-79; Baum 1981: 89f. In hindsight, it is easy to see that SDC's interest here was directed less towards developing automated school lessons and more towards creating training scenarios for military personnel in complex organisational and decision-making scenarios. Accordingly, a SDC image film treats the development of TMs more as an appendix and focuses much more on training scenarios for SAGE air space security employees (*System Technology* (approx. 1960), directed by System Development Cooperation (distributed via Prelinger Archives; [https://archive.org/details/6240_System_Technology_01_29_28_19]; last accessed on 28 October 2016)).

27 In his paradigmatic text, Skinner—almost in passing—also refers to the usability in a military environment: "Self-instruction by machine has many special advantages apart from educational institutions. Home study is an obvious case. In industrial and military training, it is often inconvenient to schedule students in groups, and

Fig. 10: Computer Based Laboratory for Automated School Systems (CLASS) / System Development Corporation (1963) (source: Baum 1981: 86ff)

In this respect, and viewed more abstractly, TMs could be seen as a 'systemic reaction in terms of control policies' to a state of crisis (lack of teachers, new challenges in education), at the core of which lie consequences related to control policies. The fact that learning machines were developed and used in socialist countries is proof that this crisis was not just a Western problem (cf. e.g. Schestakov (ed.) 1965; Vogt 1964). One of the main 'causes' of the perceived need for a radical increase in effectiveness in school education was the sense of a political-ideological deficit. In light of the Sputnik crisis,[28] the Western world appeared to lag behind the achievements of the socialist bloc and, in the course of post-war economy and the looming cold war, seemed to have to make an effort to remain dominant from a technological and 'epistemological' perspective (Foltz 1961: 17). Without delving too deeply into this argument, it nonetheless indicates that dealing with TMs without embedding the topic into other 'governmental systems' does not make sense. TMs may be understood as technologies

individual instruction by machine should be a feasible alternative. Programs can also be constructed in subjects for which teachers are not available—for example, when new kinds of equipment must be explained to operators and repairmen, or where a sweeping change in method finds teachers unprepared" (ibid 1958: 976).

28 The Sputnik crisis refers to the political-societal reaction (primarily) in the USA to the Soviet Union's launch of the first satellite, Sputnik 1, in October 1957. This launch forced the public to recognise that the Soviet Union was at least equal to the USA when it came to technological aerospace developments during the cold war. This created a 'feeling of inferiority' that could possibly be assessed as a form of 'crisis of control' within the meaning of Beniger (1986: cf. footnote 29).

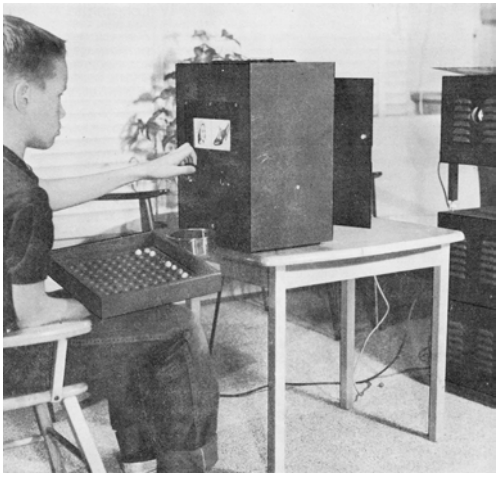
that primarily intervene in the process of (literal) 'self-education' as an agency related to control policies.

Crises of Control

It therefore makes sense to view TMs as 'machines' of 'self-production' when transferring the topic to today's gamification. Almost every source assesses TMs as an 'answer' to a crisis of control: The blatant lack of teachers, the changing requirements with regard to a subject's knowledge within a globalized, industrialised world and the necessity of flexible forms of control—all of this is taken to indicate the necessity to radically change course. And of course, this configuration may be interpreted as a crisis of control that can be described using the theories of James Beniger (1986) and that sparked the TMs' revolution of control.[29] The crisis of 'education' and of the student (caused by an increasingly complex world and increasingly complex knowledge, the lack of teachers and the challenges of new (media) technologies) gives rise to a situation of upheaval that 'solves the problem' and at the same time implements a new system of rationality. This crisis appears to have many causes: a general lack of teachers, the absence of a structural reform in the educational sector, the supposed effectiveness of a competing education system (Eastern bloc) as well as the plain backwardness of educators who are not open to the possibilities of new technologies and current scientific approaches. No matter how we set up the argument, it 'constructs' a crisis that TMs are supposed to provide an answer to. The crisis of the education system is followed by the TMs' revolution of control, which does not just introduce another instrument to the discourse on education, but rather merges the epistemology of operant conditioning and the governmental practice of self-techniques with one another. From this perspective, TMs and other educational means of similar design are a consistent continuation and respective renewal of these revolutions of control.

29 James Beniger (1986) views the process of industrialisation as the interplay of crises of control and revolutions of control: "As the crisis of control spreads through the material economy, it inspired a continuing steam of innovations in control technology. These innovations, effected by transporters, producers, distributors, and marketers alike, reached something of a climax by the 1880s. With the rapid increase in bureaucratic control and a space of innovations in industrial organization, telecommunication, and the mass media, the technological and economic response to the crisis—the Control Revolution—had begun to remake societies throughout the world by the beginning of this century" (ibid. 429).

Fig. 11: Teaching machines as a means of 'breaking the subject in': "The Osler-Foringer Discrimination Device for tests with children at special-needs schools; the device projects pairs of images onto a screen. The device can be used to present various types of tasks. Marbles reward correct answers, the students' results are recorded automatically" (Foltz 1965: 54).



Shortly after Skinner's aforementioned article, it became apparent that the 'TM project' had been launched too quickly and without substantial conceptional, economic and educational support.[30] Criticism quickly arose that ultimately characterised the educational concept of operant conditioning as 'breaking the subject in' (cf. Vogt 1966: 77). The possibilities of actual, functional learning using TMs in the context of 'holistic' school education was considered limited: "One critic noted that it might be possible to learn a poem using one of the machines, but the machine

30 "Other serious concerns involved the corporate claims for the machines and ways in which they were marketed. [...] Several of the relevant professional organizations grew concerned about these and other problems and sought to develop guidelines that would aid consumers. The American Educational Research Association, National Education Association, and APA all collaborated on a joint statement on 'Self-Instructional Materials and Devices' (1961) and a lengthier report ('1962 Interim Report', 1963). [...] The published report emphasized the importance of successful programs in providing quality teaching by machine and listed criteria for assessing program effectiveness. The Committee cited a need for research on the relative effectiveness of different types of programs but did not call for research comparing teaching machine with more traditional teaching methods. Not surprisingly, psychologists were divided on the efficacy and desirability of these devices" (Benjamin 1988: 710).

could not teach the love for poetry".[31] Another frequently asked question, not least to articulate a certain scepticism towards machines, was whether presenting learning materials that had specifically been prepared as a 'programme' really needed a machine, or whether said machine was merely a 'page-turning device' (Benjamin 1988). In any case, the automated control effect that Skinner and others ascribed to TMs was questioned, a criticism that had a sustainable and lasting effect: Benjamin (1988: 711) speculated whether teachers' hesitance to admit computers into their classrooms in the late 1970s and early 1980s could ultimately be explained by their experience with the TMs' promises (which were not kept).[32]

At this point, my interest is not in delving deeper into this discussion from an educational perspective. The more interesting point (including in light of today's discussion on self-learning) is whether TMs can be understood as the nucleus of a development of subject effects within the meaning of (Foucaultian) politics of self and governments of self in the context of the use of 'educational means'. In contemporary criticism of TMs, a perspective has already become apparent that focuses on examining the conditions and possibilities of the 'involvement' of creative, self-conscious subjects that do not act 'rationally' in the actual sense.[33] Clark C. Abt's renowned book *Serious Games*, for example, can thus be interpreted as an alternative to the TM euphoria. Particularly in regard to TMs, Abt's specific view of the subject position that is to be created is remarkable. Here, the conflict that developed between Abt's subject concept and (Skinner's) behaviouristic subject logic is apparent (and it almost seems as if Abt's subject has gained a stage win over the concept of 'programmable' and 'trainable' subjects with the swift end of the boom in TMs). A critical position has also been articulated with regard to the status of the learning subject within the TM discourse; even Skinner doubts the complete rationality of his learning concept. He talks about the 'pinball-machine-effect': the fact that, beyond the programmed educational content, the learning machine itself interrupts the student's gaming operation. Similar to pinball machines, there is a risk, says Skinner, of interactions with the learning machine challenging the gaming operation to such an extent that the student's drive to beat the machine itself (in other words, to win the game) could become more dominant than the learning effect and internalisation of the material that is to be mastered (Foltz 1965: 47). In a nutshell: The various apparatus and architectures of automated learning again and again appear to develop a 'life of their own' besides their intended (action-)rational functionality. Learning that uses 'ludic' methods becomes learning that constantly seems threatened by the 'game'.

31 Margolis, Richard J. (1963): Do teaching machines really teach? Redbook, S. 98-99.; cf. Benjamin 1988.

32 "However, use of computers in the classrooms of the 1960s and 1970s was very minimal. Even Skinner, in a 1968 interview for Forbes magazine, doubted the future of the computer as a teaching machine [...]" (Benjamin 1988: 710).

33 For more on the problem of 'involvement' as a concept, cf. Neitzel/Nohr 2010.

Abt, and his serious gaming approach, give this effect a positive outcome[34]—however, the pinball-machine-effect (among other reasons) causes the TMs to fail. Engaging with the TMs proves that the subject's status as a complex, acting entity is far more complex than the characterisation of 'educational-game-technology' hybrids initially suggests. The step from Paidia to Ludus seems to evoke a dissident, resistant subject that avoids serious games. In the end, however, this resistant subject is an idealisation on the one hand and only supposedly emancipatory on the other.

And this is possibly one of the main reasons why the concept of TMs was doomed to fail: the learning theory of behaviourism soon proves insufficiently complex to do justice to the actual education situation. Skinner's concept of operant conditioning seems to demonstrate too little complexity—not least in light of the Central European history of education, from John Amos Comenius and Johann Bernhard Basedow to Wilhelm von Humboldt. Nonetheless, and in light of the evident criticism of behaviourism, the question remains as to why both the concept of serious games as well as that of learning machines and software are currently experiencing a comeback and why on close inspection, on the other hand, a whole range of current educational concepts appear to be influenced by behaviourism?

Let us return to the TMs. In hindsight, these may seem antiquated, with an insufficiently complex effective approach and an almost naive, technophile creative drive. But what distinguishes TMs from today's software-based learning projects? Vocabulary learning tools such as Duolingo and classroom tools such as moocs and Moodles essentially use similar mechanisms to those assessed as serious games as early as 60 years ago. Drawing a direct line from the 'teaching machines' of the 1950s and the self-instructional learning of the 1960s to today's debates on (ludic) self-instruction therefore seems an obvious step. And accordingly, we finally have to ask which crises of control (and not just: which epidemologically induced states of emergency and neoliberally induced effectiveness crises of the educational sector) ostensible, current classroom tools react to and which specific subject concepts are demonstrated by today's functionally designed tools of gamification and serious games?

34 Abt compares the TM's rationally acting subject to an intuitively acting subject that is not characterised by its position of strategic consideration but instead by its intuitive decision-making ability within the framework of a ludic role-rationality. At the core of the serious games, there is a subject that—to be blunt—is not 'controlled' by a superordinate, teleological or cybernetic logic nor 'broken in' by a lucid learning algorithm, but instead uses its own intuitive capacity to act, identifies itself by identifying with and embodying role offers (and problems) and develops creative solutions based on a pre-structured process.

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