

Knowledge Technology

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Abstract. Language – writing – printing – media communication—regulated flow of information: Academic knowledge is about technology. Knowledge is shaped by the regulation of information flows. The discourse of authors is a fundamental part of these regulations, but only a part. Knowledge is not the result of discourse but of organisation. The essay uses the university system, the journal system, the Turing-machine and Lichtenberg’s physics to prove this. It shows how quality, coherence, progressive diversity, sustainable permanence, and mechanisms for testing, reproducing, transmitting, and supplementing what has been achieved emerge from organised quantity. The thesis of the essay is that academic knowledge is a technology that continues to produce technology.

Keywords: technology, knowledge, science, universities, journals, Lichtenberg, discourse, discourse organization, Turing-machines

My thesis is: knowledge is technology. What kind of thesis is that? What is knowledge? What is technology? The best definition of technology seems to be that technology is everything that increases the potentiality of the individuals of a species beyond the potentiality inherent in a single individual. Simple examples of this are a hammer or honeycombs. Technology is not limited to humans.

What is knowledge? Plato said it is justified belief. Since then, philosophical epistemology has debated when and whether justified belief can ever be achieved. Michael Polanyi further complicated the matter at the end of the 1950s by referring to implicit, unspeakable knowledge. “We know more than we are able to say,” he said.¹ A famous example of this is that you can’t say why you can keep your balance on a bike. The knowledge I would like to discuss is academic knowledge—that is, scholarly knowledge and, since the eighteenth century, the knowledge embodied in the sciences and humanities. In many respects, this knowledge also includes

1 Polanyi, *The Tacit Dimension*, 4.

non-justified belief and implicit knowledge—for example, the experience of observing processes properly. The knowledge I analyse is based on communication and interaction.

In its weakest sense, the thesis means that knowledge uses technology, but that knowledge and technology are created by innovative minds. In its strongest version, the thesis means that knowledge is based entirely on technology; that knowledge is also technology in its substance, and that technological knowledge thus continues to produce technology. To summarize: Knowledge is technology and continues to essentially produce technology.

If this thesis is to make sense, two conditions must be met. The first condition is that technology is part of evolution. I could make it easy on myself and point out that everything, without exception, including culture and intelligence—as far as we now know—is part of evolution. However, I will make it a little more difficult and show that knowledge technology is based on selection, which enables further selection, and that its development is therefore not a straightforward, let alone teleological process. It is rather—if you will allow me the comparison—the technological weather at a certain time in a certain place in the context of the technological climate. The second prerequisite is that if the assertion ‘knowledge is technology’ makes sense, it must be possible to produce knowledge—potentially at least—without the participation of authors. That sounds theoretical. But as a historian, I am an empiricist. I do not peddle theoretical reflection, but rather empirical examples.

This essay consists of four parts. In the first part, I will talk about the elements and characteristics of knowledge technology. In the second part, I will use the example of the ‘university’ to demonstrate how the elements and characteristics interact. In the third part, I will show the production of authorless, evolutionary knowledge using the example of academic journals. Finally, in the fourth part, Lichtenberg will be the witness for my thesis.

Elements and characteristics of knowledge technology

It is obvious that knowledge is technology. Knowledge was based on language, then also on writing; as academic knowledge since the fifteenth century, on printed material, and now—whether we like it or not—on digital data. Phonetics, the alphabet, printed text and digital data are the milestones in the development of knowledge up to now. From antiquity, knowledge has been composed of *scientia* and *techne*, i.e., of art and technology and thus of knowledge production on the one hand, and of its result, the “totality of human knowledge, insights and experiences of an epoch, which is systematically expanded, collected, preserved, taught and passed

on,” according to the German *Brockhaus Encyclopaedia* (hereafter, ‘*Brockhaus*’).² The *Brockhaus* already refers—consciously or unconsciously—to technology in relation to its expansion, collection, preservation, teaching, and passing on as characteristics of *scientia*. The French *Encyclopédie* divided the human mind into memory, reason, and imagination, which are also based on technologies: the technologies of memory and logic, as well as the skills of thinking, communicating, and formulating.³

If we combine the sign technologies of speaking, writing, printing, and digitizing with the data processing presented by the *Brockhaus* and the *Encyclopédie* as human knowledge, two basic elements and characteristics of knowledge technology emerge: universality on the one hand and the ability to communicate on the other.

Universality and communicability have developed more and more in the course of the development of knowledge technology. Language gives names to all things; writing materializes language on a carrier medium and thus removes the boundaries of time and place from what is said: what is said can be repeated in completely different places and in later years, even by simply reading it, without it having to be performed. Spoken words can be reproduced. Writing reinforces this. At the same time, writing adds a number of other techniques to the original technique of speaking. The carrier medium must be produced and negotiated. The documents must be written and can be administered. On the one hand, correspondence leads to a division of labour; on the other, it leads to writers and readers—to writing technicians, who—if you will allow me the anachronistic expression—stand as experts in opposition to those who have not mastered the technology and have no access to it. Third, correspondence gives rise to institutions: Administrations, whose procedures are based on writing, and authorities such as monasteries, which selectively collect and reproduce what is written. Fourthly and finally, it becomes possible to control knowledge as written material in a new form. Coherence is no longer tied to oral test procedures, such as disputation. The coherence of any statement and the details of statements can now be scrutinized individually, independent of time and place. The technology bundle ‘writing’ puts knowledge in a new epistemological position. In short, further knowledge technology has emerged from the knowledge technology ‘language’ that supports the development and differentiation of society, but at the same time also enables the continued evolution of knowledge technology. With printing, the knowledge technologies of managed signs reach a new level. A lot of clever things have been written about this—you will certainly be familiar with the work of Eisenstein, Goody, McLuhan, Giesecke, and many others.⁴ As with the step

2 *Brockhaus Enzyklopädie*, 19. ed., vol. 24, Lemma Wissenschaft, cited by Wikipedia “Wissenschaft.”

3 Cp. le Rond d’Alembert, “Explication détaillée,” xlvij–lj.

4 Eisenstein, *The Printing Revolution*; McLuhan, *The Gutenberg Galaxy*; Goody, *Literacy in*

from spoken to written language, the transition from writing to printing adds new technologies to the old, and with them new apparatuses, networks, and institutions. Writing takes the words out of the speaker's mouth and puts them on paper. Printing takes the words out of the author's writing hand and hands them over to an apparatus. The apparatus is more than just movable type and a printing press. It includes printers, publishers, workers who build and operate the types and presses, paper-makers, etc. Above all, the apparatus includes the emergence of the literary market. With the printing press, knowledge technology not only inscribes itself into society. With the networks and economies generated by the production of type and presses, printing and publishing, distribution, circulation, administration, and, of course, first and foremost, the reception of texts, knowledge technology is transformed into the central organ of social organization. Knowledge technology becomes society. If written material is addressed to recipients, printed material is addressed to the market and the public. Once again, the new knowledge technology is associated with new epistemological possibilities. Once again, quantity turns into quality.

The printed text allows the differentiation of text genres, and it can be multiplied in an inflationary manner. This allows for identical collections of texts in all places where they are needed, and as far as the knowledge unit 'book' is concerned, with specific library profiles in each case. The moment knowledge becomes a question of supply and demand, criticism of knowledge can be differentiated and grouped. The respective knowledge is given its place on the knowledge map and can be advertised there.

We have taken the next evolutionary step towards digital data. 'Knowledge technology becomes society' is the label applied to book printing. This is now being inverted: Society is becoming knowledge technology through the universal accessibility and publishability of knowledge in real time. We are all part of this sender-receiver system that achieves the ultimate universality and communicativeness.

University: the elements and characteristics of knowledge technology in operation

If *scientia* is about expanding, collecting, storing, teaching, and passing on knowledge, then it is an apparatus. It was a good idea to realize "the whole epitome of scholarship in a factory-like way, by distributing the work," namely, through universities,

Traditional Societies; Giesecke, *Der Buchdruck in der frühen Neuzeit*. Behind the question of knowledge and technology lies a broad field of research, ranging from science and technology studies and the 'science in context' approach to laboratory studies and actor-network theory, media, collection and archive research, paper technologies, alphabetization research and the expansion of information technology to social technology and the anthropology of technology.

as Kant wrote at the beginning of the *Der Streit der Fakultäten*. There are depositors of knowledge for all subjects—people who administer the knowledge and use it to train the apprentices, i.e., students, to become “businessmen or workmen of scholarship” and thus “tools of government,” i.e., clergymen, judicial officers, and doctors.⁵ Kant’s point is that because the knowledge of the upper faculties is factory knowledge, philosophy is needed to control knowledge. The fact that philosophy also has a technical function can be disregarded here for now. More interesting is the idea of knowledge as a technical process. What is given is the network of universities with the individual universities as nodes and the diverse connections between the universities as network edges. Within the individual universities, subject areas are represented by and assigned to faculties, i.e., coordinated alongside each other. This constellation of knowledge, subdivided and networked as specialist knowledge, specifically modeled in line with the knowledge profiles of the individual universities and at the same time assigned to the university network, provides the technical framework for the processuality of the knowledge production of *scientia* in the expansion, collection, storage, teaching, and transmission of knowledge. In the networks and constellations of universities, we are dealing with a structured mechanism that allows that all these features be carried out in relation to one another, i.e., synchronized.⁶ Knowledge production follows the rhythms of the university and the media with which knowledge is communicated (Figure 1).

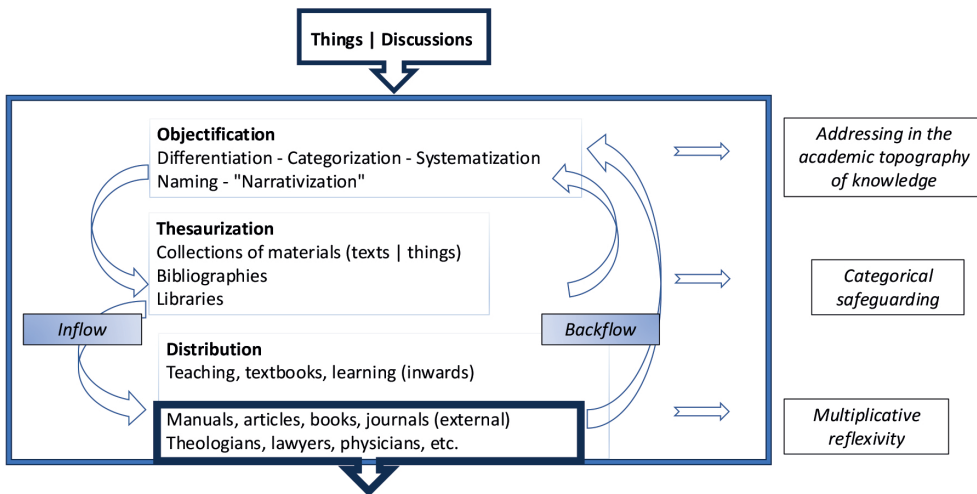


Figure 1 Processing knowledge in universities

5 Kant, *Der Streit der Fakultäten*, 3.

6 Cp. Gierl, “Synchronisation.”

Things and their discussions are brought into the university. There they are objectified in the body of knowledge, thesaurized, and then communicated both internally and externally.

What takes place in all fields of knowledge is an objectification of the subject of knowledge, which is associated with the dissection of the subject into categories and the parts assigned to the categories. The Bible has an Old and a New Testament; the flower has a base, sepals, petals, stamens, and pistils. All parts are named and thus lead the way to specific technical languages, which, in their unambiguousness, enable technical discourse and, at the same time, specific functional discussions about things. The technical operations of categorizing and describing knowledge lead, on the one hand, to the possibility of thesaurizing knowledge in an orderly fashion and, on the other hand, to the possibility of processing the objects of knowledge in a subject-specific manner. With the classification and discussions of new things within the subject system and its categories, they are 'narrated,' i.e., the description of knowledge is supplemented and modified. Mathematics is described mathematically, history historiographically.⁷ A bone can be discussed anatomically, evolutionarily, pathologically, physiologically, surgically, ethnologically, and archaeologically. Behaviour, to give another example, becomes a cultural, sociological, historical, philosophical, theological, or legal thing in the processing.

The objects of the input are thus addressed in the academic topography of knowledge.

Processing knowledge is a medial and at the same time tangible material event. Things are transformed into text. They are turned into books and thesaurized as books in collections. As with texts in libraries, they are made accessible with the help of catalogs and bibliographies. Knowledge is categorically secured in the process. The body of knowledge is communicated internally via teaching, textbooks, and learning. It is processed into texts in various media and brought to the outside world. At the same time, the supplemented body of knowledge feeds back into the grid, which controls the further absorption of things and discussions.

Authorless, evolutionary knowledge production—journals

The fact that the transformation of things into academic knowledge is a multiplicative process is important in two ways. Since technically multiplied knowledge is created, which flows back into the knowledge precipitation process with further multiplied knowledge—i.e., since knowledge expands in continuous selection spirals—,

7 To process an object of knowledge professionally means to process it according to both the characteristics of the object and the social purposes of the subject area.

it can be assumed that knowledge technology in action is an evolutionary process. The second point is that with the differentiation and simultaneous multiplication of knowledge, quantity turns into quality. Form becomes content.

Knowledge does not only result from discourses, and discourses are not only based on the communication of authors. The separation between knowledge and something understood as context is historically not real. In real terms, the networks of context, such as the media, institutions, infrastructures, tools, procedures of communication, etc.,—ultimately everything that has constituted flow—are active components of knowledge production. Knowledge is not a result of discourse as such, but more generally of the organization of information.

The scope and composition of authorship are examples of this. Distinctions interact. They lead to differentiation within differentiations. In the 1760s, one assumes 2,500 authors were present in the German lands, in the 1790s, 7,000, and in 1810, about 12,500 authors. This means that what was known about state, religion, world and man developed not only because there existed Hobbes, Spinoza, Locke, Hume, Kant and some others, but because in 1810 there were twenty times as many authors as in 1650, writing in specialized media about newly developed subfields associated with general subjects.

Journals are another example of the organization of information. Journals define the knowledge belonging to a field and control its publicity, periodicity, and topicality. Publicity, periodicity, and topicality are powerful but complex parameters. It can be said, however, that publicity, periodicity, and topicality are meant empirically as the status quo of all reading and writing processes in a field. Reading and writing processes are subject to differentiation.

To get an overview of journal production in the German lands, I used Joachim Kirchner's standard bibliography of German periodicals.⁸ The bibliography lists 6,700 productions, of which Kirchner has classified 4,700 by content. Using Kirchner is not without problems.⁹ However, Kirchner's bibliography at least maps some central developmental steps (Figure 2).

From the beginning to 1750, about 500 journals were founded. This is the line of transparent cubes in the diagram. Dominant are general periodicals indicated in blue with 167 productions, followed by theological and locally focused journals—in the diagram, brown. One could call them lifeworld journals. The third relevant group in orange includes politics, literature, jurisprudence, medicine, and medically oriented natural history journals. I call this group social-organizational journals. In sum, until 1750, we are dealing strongly with the basic differentiation of the periodical market.

8 Kirchner, *Bibliographie der Zeitschriften des deutschen Sprachgebiets*, vol. 1: 1670–1830.

9 Published 1969, the classification scheme is historically problematic. Kirchner's categories reflect the library system of the twentieth century.

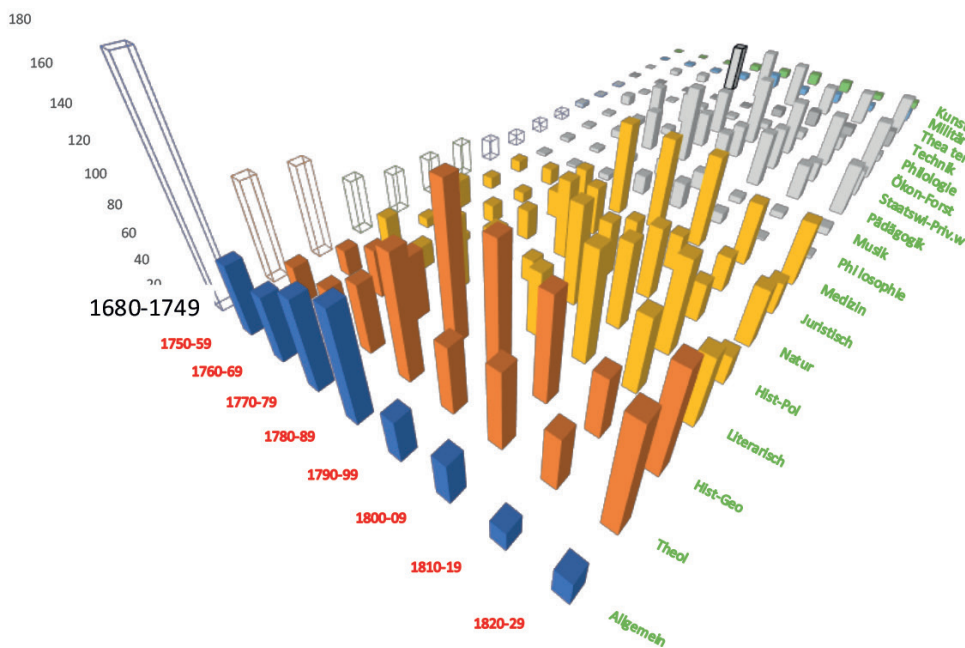


Figure 2 Foundation of journals, Germany, 1680–1830

	General content	Church	Local	Literature	History and Politics	Nature	Legal	Medicine	Philosophy	Music	Pedagogy	Economist	Agroforestry	Philology	Technology	Theater	Military	Art	
-1794	167	80	74	45	34	31	29	18	10	9	7	4	1	1	1	0	0	0	511
1750-1759	55	30	21	28	8	24	10	10	2	3	2	2	9	1	1	4	2	0	212
1760-1769	51	31	38	19	6	15	9	14	2	3	7	6	27	1	0	7	2	1	239
1770-1779	70	54	51	57	4	25	23	26	5	6	36	6	28	4	1	46	5	5	452
1780-1789	85	94	117	64	19	63	40	76	16	14	67	31	40	3	1	47	13	7	797
1790-1799	32	52	97	51	78	45	26	75	22	15	36	29	60	5	7	41	6	11	688
1800-1809	31	60	81	85	67	56	29	73	9	5	47	37	48	7	14	27	9	10	695
1810-1819	15	41	47	59	73	30	28	50	1	5	30	17	45	12	8	30	6	5	502
1820-1829	19	84	80	54	22	45	25	50	2	6	42	22	50	6	15	34	9	6	571
	525	526	606	462	311	334	219	392	69	66	274	154	308	40	48	236	52	45	4467

Table 1 Foundation of journals, Germany, 1680–1830: ten-year intervals

From 1760 to 1790, specialized journals emerged that not only served general areas of social regulation, such as law and medicine, but also created special organizational fields, such as history, economics, technology, philology, music, theatre, and the military. These specialized journals were the medial background for the development of disciplinary journals.

The period as a whole is characterized by an exponential increase in the number of journals founded in the German lands. While 500 journals were founded in the seventy years leading up to 1750, 800 were founded in the 1780s alone. All specialized journal rubrics of Kirchner show exponential growth in this phase. I have highlighted the massive jumps in green in the table. The increases point to a phenomenon central to information organization. They point to transitions from journal genealogies to journal clusters (Table 1).

Journals initially legitimized themselves by being successors to other defunct journals, before appealing to the need to treat a subject context that had not yet, or locally not yet, been observed. The trend was from the differentiation of the overall market to expansion and interaction within individual fields. If there is only one journal per field, these journals will communicate across field boundaries. However, if there are several journals per field (i.e., journal clusters), the journals interact primarily within the cluster. Communication within the field becomes self-sufficient. Again, differentiation and quantity transform into quality. We find that there is not only steady growth, but there are also exponential declines. I have highlighted them in yellow. In the background are political and social upheavals—the French Revolution first, then the Napoleonic wars, the breakdown of the Old Empire, and after 1815, the Restoration.¹⁰

It is relatively simple and, above all, coherent in terms of content to show how thoughts developed from Hobbes to Kant and so on. Thus, the classical history of knowledge can exclude the influence of information organization and knowledge technology and mostly does so implicitly and explicitly. It says: you only need Hobbes, Locke, Hume, and Kant, and no information organized from outside to get from Hobbes to Kant. Proponents of evolutionary information and, ultimately, knowledge technology seem to have a harder time of it. They have to show that knowledge of Hobbes and Kant is also possible without Hobbes and Kant, solely a result of the technological selection of information. The model for this, however, can be formed surprisingly simply. As the journals show, it is not just a theoretical model, but an empirically based one. The model does not grasp or map the

10 The differentiation, the leaps, and above all the declines indicate that the transformation of information into knowledge is not based on a vague relation between society and discourse, which would be just a truism, but on the organized technological transmission of information among representatives of society and representatives of discourse.

horrendous complexity of historical organization, but it does outline its potential. My empirical model of journals and information organization in general connects Borges’s Babylonian Library with the Turing Machine.¹¹

Imagine books two hundred pages thick and a core character set consisting of a basic alphabet, a comma, a period, and a space—that is, twenty-five characters. Let one page of each book have forty lines, each line eighty characters. That is, there are twenty-five times twenty-five times twenty-five and so on possibilities per line. In total, twenty-five to the power of eighty possibilities. Each page has forty lines—that is, twenty-five to the power of 3,200 possibilities to combine characters—and the 200 pages have twenty-five to the power of 640,000 possibilities. That is, the library has twenty-five to the power of 640,000 books. They contain everything that can be written on 200 pages. It is an incomprehensible number of books, albeit a finite one (Figure 3).

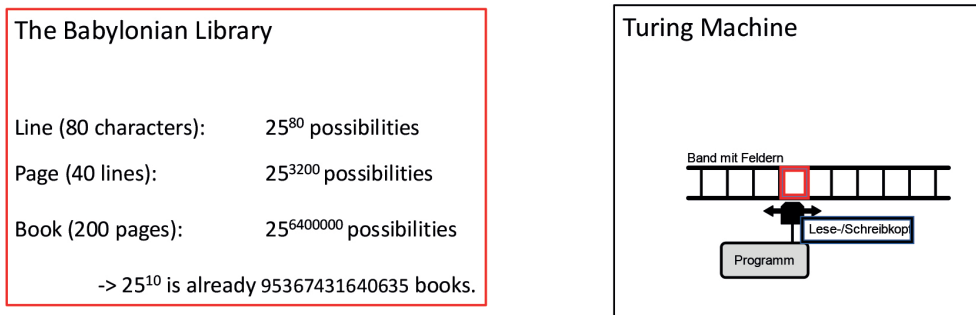


Figure 3 The Babylonian Library and the Turing Machine

But this has a problem: Everything that is contained in the Library in terms of sense is swimming connectionless in a gigantic ocean of nonsense. One needs a selection mechanism; that is, an organizational mechanism that brings the bits of sense in the ocean of nonsense together. Such an organizational mechanism exists, and it has existed since the beginning of civilization. It has been formed culturally and technically through the development of language, writing, alphabet, and printing, specifying the sender-receiver units and with them topicality, publicity, and periodicity. It now unmistakably defines history and our lives. It is the Turing machine.¹² The Turing machine consists of three parts: A tape of fields, a read-write unit, and a program. The program understands characters and vocabulary and assigns action grammar to them. The machine reads a field, rewrites it, then, depending on what it has read, goes to the right or left field or stays where it is, and it then repeats. The machine generates

¹¹ Borges’ La Biblioteca de Babel is part of Jorge Luis Borges, *El jardín de senderos que se bifurcan*.

¹² Turing, *On Computable Numbers*; Oghihara, *An Introduction to Theory of Computation*. Cp. also Bremer, *Ist alles berechenbar?*

topicality and periodicity. It selects and thus organizes information. The machine is not actually of immense importance as a rudimentary computer model, but because Turing used it to prove mathematically that algorithms, i.e., rules of action, can be mathematized. It is one of the foundations of theoretical computer science. Go to the right field, go to the left field, or stay: The Turing machine, as a decision model, is at once a general model of organization and a general model of history. Reading and rewriting a field is what happens when people, put in a situation, interpret and react to the situation. The Turing model is a model of what historic events are. History would thus be a thing that is more and more able to define fields—that is, markets, networks, groups, events, etc.—and to organize sender-receiver chains in them—that is, to react on organized constellations.

If I were younger and smarter, I would have started a project on how the mathematics of the Turing machine can be applied to history and vice versa. It would be a project about the possibilities and limits of making history science. And it would provide answers to the question of what events are.

Journals are only one element, and the media are involved in the huge process of assembling and formatting knowledge. However, the journal network is organized as a simple reading and writing apparatus that drives knowledge production. The basic pattern is that a field is defined and read out; what is read out is organized and brought back to the field via a journal. From this derives a far-reaching hypothesis: Knowledge is designed through the regulation of information flow. The discourse of authors is a fundamental part of these regulations, but it is still a part. Knowledge is not the result of discourse, but of organization.

Journals are quite illustrative of the technical processing of knowledge, I think.

Lichtenberg and physical research as coordinated technology of knowledge

Contemporarily, Lichtenberg was not known for his sayings, but for his physics lectures. He became a full professor in 1775 and a full member of the Göttingen Academy a year later. His duties at the Academy included proposing physics-related prize questions and, after the Academy had posed them, assessing the answers it received. In the university, he gave the main physics lecture, in which he presented several hundred experiments based on his collection of instruments.¹³ The fame of this lecture and of Lichtenberg's physics was built on the gadgets and Lichtenberg's ability to present them. The content of the lectures was based on the textbook by his predecessor, Erxleben, which he revised several times. Lichtenberg only referred to ninety physical

13 Cp. Lichtenberg, *Vorlesung zur Naturlehre*.

compendia and texts for his lecture; on the other hand, to twenty-one journals and forty-one academy periodicals from thirty-eight European academies of science.

As a physicist, Lichtenberg was particularly interested in heat. It was the “soul of all organic and inorganic physics.”¹⁴ Lichtenberg’s preoccupation with heat is a vivid example of the interplay of instruments of knowledge as knowledge technology.

In 1786, Lichtenberg submitted eight questions to the Society as possible prize questions: two questions on thermodynamics, i.e., the absorption of heat; question three on the improvement and mathematical explanation of a water-lifting machine, questions four and five on the function of barometers; question six on the significance of time measurement in physics; seventh, a question about the gravity of the earth, which had been suggested by the late Göttingen astronomer and academy member Tobias Mayer, and eighth, concerning the intensity of the earth’s magnetism. At the time, Lichtenberg would have liked to have posed question six on the measurement of time. Blumenbach voted for a better understanding of the barometer. Lichtenberg’s classmates Meister and Kästner, however, preferred question three. The rest of the society agreed. So, question three was used.

In 1790, the Dutch Academy asked about the cause of heat. The *Göttingische Gelehrten Anzeigen* published the question. Lichtenberg thought about answering the prize question. At the same time, he made notes in his physics notebook: What is the thing called fire? Is it different from light? What is known about heat? He added references to contemporary theories. When he was invited to give a speech at the Göttingen Academy in 1792, he wanted to make the theory of heat his topic.¹⁵ In 1798, it was again up to Lichtenberg to propose prize questions. The senior of the mathematical class, Abraham Gotthelf Kästner, chose two of them. The “circulation” of the questions among the academy members was meanwhile “only a ceremony,” Kästner wrote to Lichtenberg.¹⁶ Now, the question on heat conduction in water vapor was adopted.

The interwoven and interrelated use of knowledge instruments—the professorship, the academy membership, the lecture, the physical apparatuses, the textbook, the compendia, the periodicals, the academy speech, the academic prize contests, the procedure for choosing questions—in other words, the technology of knowledge in action—led Lichtenberg to the category of “heat” and brought the question of the difference between fire and heat flow to the table.¹⁷

14 Gamauf, “»Erinnerungen aus Lichtenbergs Vorlesungen«.”

15 Cp. Lichtenberg, “Zur Leitung und Reflexion der Wärme gehörige Versuche.”

16 Cp. Lichtenberg, “Briefwechsel.”

17 Cp. Lichtenberg, “Zur Leitung und Reflexion der Wärme gehörige Versuche.”

My summary is: If one recognizes that knowledge production means technology, the view turns. Instead of searching for content and culture in supposedly autonomous subjects, ideas, and theories, we begin to analyse the constellations and networks in which knowledge is formed. We follow how knowledge evolutionarily emerges from information and technical interaction. We historize knowledge.

And we scientify the field. Is not it remarkable that historiography, which has classically and consensually defined itself as a “narrative of memorable events,” instead of reflecting on what historical events are, made the narrative stronger during the fervour of individualism at the very time when physics, chemistry, biology and geology became sciences because they succeeded in defining physical, chemical, biological and geological events? If historiography wants to have something to say and not just to represent opinions, it is a matter of saying something about how history operates, functions, and develops as a sequence and network of events in constellations. We need to know how historical constellations and their internal coherence emerge, and we need to know what historical events are, how quantity changes into quality, and form becomes content.

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