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Editorial: How can we get technology taught in schools?

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How can we get technology taught in schools?

1 Starting point

"How do we get technology taught in schools" is a question that is increasingly being asked by those parts of our educational system which impart technical skills, i.e. vocational schools, businesses and technical colleges. It is not only because of demographic changes that technology-oriented areas of post-school education are faced with quantitative but also qualitative youth shortages. Fewer and fewer young people are choosing a technical education while the basic technical skills of future generations are decreasing. To quote an instructor of a large company: "half of the trainees we chose to have this year for the job of industrial mechanic could not even perform simple repairs to a bike".

In addition to fields of research and development, our economic system, due to its enormous need for qualified engineers and technicians, is facing increasing problems because of the "general education deficit in technology". Since the beginning of its advance in the 1990s, the digitization and computerization of all spheres of life has been poorly understood in technical terms by broad sections of the population. From the outset the world of technology became divided between technicians and users, but in the early years this was regarded less as a problem than a beneficial deficit. With the ubiquity of a fast networked digital world, however, former use deficits are now developing more and more into security deficits. The user is now increasingly the "loser" as in a technical world that he or she must use, users are unceasingly and inevitably exposed to large security risks to savings, data, personal life, children, etc.. Thus, there are reasons that technology should have a much greater emphasis in general education than it has so far received both for the sake of our productive-economic development, but also for our social development. Why this is easier said than done is discussed in what follows.

2 Technology – A product and engine of civilization

Culture is what people either make themselves or create by engaging with nature. It includes the arts, religion, language, morality, politics, law, the economy and - technology. Culture therefore includes rational aspects (technology for dealing with nature), social aspects (language for communication, morals for value-orientation, politics and law for an orderly coexistence and economics for the exchange of labor) and transcendental aspects (religion for answers to the big questions, art of the irrational). Here, technology is a fundamental condition for civilized man because without it he would not be able to rise above nature. Technological advances are both the cause and effect of social progress because in the course of the technical achievements of past epochs, human communities have developed out of the herd and into their present state. Societies have thus developed in the course of technical progress, but not exclusively as a result of them. Social development is carried out either through the implementation of technological progress (for example, education has been advanced by the printing press), or as a related adaptive response (urbanization as a result of industrialization). The transcendental aspects of culture are generally seen to be technology-independent, but they are also sustained by the continued influence of technology (e.g., through new forms of expression in painting using new surfaces, colors, techniques, …). It follows that all sections of our society are permeated by technology or affected in some way by it and therefore also driven by technological progress. Once a new technology is established, there follow - depending on their innovative content and situational relevance - different waves of implementation, the strength of which is determined by their overall social reception. A prominent example is the technical-productive cycles of transformation traced by Nikolai Kondratiev in the early 20th century in the form of discrete patterns the development of which could subsequently be predicted, such as the rise of the locomotive. The particular social consequences of the "Kondratiev wave" of 1780-1840 is described in Gerhart Hauptmann’s novel "The Weavers". We are now experiencing the fourth decade of subsequent waves of computerization (personal computer in the 1980s, the internet in the 1990s, mobile devices in the 2000s, "total digitization" in the 2010s). In summary, if you look into the history of mankind to this day, technology has a comprehensive and fundamental place of importance for civilization. This involves the fact that technology only moves forward, it does not turn around or stop and it can not be predicted how quickly it progresses, or in what direction (for example, fuel cell or nuclear fusion). Technology is value neutral in itself, but this is affected by the form of its (mis)use and the degree to which we are conditioned to use it in a responsible manner. Given the central cultural and social importance of technology, it should have a high priority in our education system, since it strongly influences the cultural identification of our younger generation in terms of their maturity and responsibility.

3 The importance of technology in the course of history

Arnold Gehlen was referring to the anthropologist Johann Gottfried Herder when he described man as a deficient being, which due to the decline in human’s physical facilities and failing instincts would now hardly be able to survive in the wild without technology. Developmentally, one must consider the converse of this, however. Homo Sapiens is, in its previous and current genetic form, a species which has not adapted to nature but has initiated by itself, and continued to pursue, technical progress. The continuing development of hand and brain went - as can be demonstrated in many prehistoric finds - parallel to the ever improving use and manufacture, of tools, weapons, clothing, houses, etc. Thus, for ancient man technology was a basic condition for survival in a natural world from which he had distanced himself physiologically.

Throughout the history of humanity the development and use of technology was a key success factor for the development and protection of habitats and resulting civilizations. In the transition from non-human communities in larger states, a technical edge initially secured dominance and power, while technology then became a means for ensuring a comfortable and aesthetic life. Early technicians were experts in applying knowledge so they could achieve things both for themselves and for the benefit of others. Their expertise was developed largely by tradition, through copying and trying out methods. Much like the crafts and guilds in the Middle Ages, technicians created their own social niches through which they protected both their know-how and its marketing through networks that give it external access and spread its influence worldwide. The original sciences of antiquity (grammar, rhetoric, dialectics, arithmetic, geometry, music and astronomy) and in the Middle Ages (philosophy, medicine, theology, jurisprudence) ignored technology for ideological reasons. Through technology the natural sciences became "open to religious compliance" and this allowed its empirical development. During the Enlightenment, however, the natural sciences could no longer be held back and this formed the basis of the interplay between science and technology: New scientific findings were increasingly implemented, while to achieve better research new technology was needed, and to advance technically natural science needed to engage in further research, etc.

Despite the significant relationship between the development of our world independent of religion and technical progress, the educational heritage of the Enlightenment did not lead to a general turning towards technology. In that time beyond Germany the momentous educational ideals of Wilhelm von Humboldt attached no importance to technology, a fact which had a fatal effect because the emerging secular school system and the susbsequent system of Higher Education to which it was related were established on its principles. While for the linguistic, human and natural sciences of schools direct connections have been made to university courses, in Germany in the 19th century polytechnics (engineering schools) arose – which were initially independent – and which later gave way to technical colleges or technical universities. There has thus always been a non-existent or minimal knowledge of basic technical relationships among freshmen in applied engineering. This exclusion of technology from general education and its special position in the field of higher education continues today; it is natural for large parts of our society to assume that "Technology is just something for engineers".

Technology has since as late as the industrial revolution been highly polarized by society into "good art" (medicine, transport, securing prosperity, mobility, ...) and "bad art" (weapons, environmental degradation, Taylorism, robotization, ...). Even in politics, technology-related polarizations emerge: the advocacy for technology has been closely associated with economic neoliberalism, while technological scepticism is alligned with ecology and socialism. In technology-related disasters (Fukushima), "technology in general" is regularly brought into question, highlighting how man is "not being able to act responsibly". Also for the "major problems of the modern world", including overpopulation, global warming and environmental degradation, technological progress is often blamed. The converse is hardly questioned, however, as the "blessings" of technology (especially in medicine, the work environment, transport and food) continue to be used and new forms of it are sought. People who are trying to exclude technology from their lives (avoidance of IT technologies, banning TV, not owning a microwave, ...) are considered isolated exceptions. In broader cases (e.g., the Amish in the United States (no cars, no electricity, no telephone, ...) leads to people simply shaking their head. Nevertheless, the Amish are highly technical (agriculture, houses, clothes, coaches, ...), but only at a lower level of development.) Technology determines us literally "from the cradle to the grave", as it not only increases efficiency and comfort, but protects our body, supplies and heals it, and feeds us, and has, among other things, caused our life expectancy compared to ancient man to almost triple. Even technology-sceptics would hardly want to give up their clothes or toothbrushes.

4 The importance of technology in education

Regardless of the polarity between "technological-skepticism" - "technological-self-realization" the gap has been established in education for a long time. However, there have always been enough people who deal professionally and scientifically with technology. Craftsmen or engineers – who specialize in particular technical aspects and for which there are experts in every field, ensure our technical progress and its economic and social uses. This is not self-evident, for craftsmen and engineers do not come out of nowhere - they need to be trained. The argument is still made that as technology already exists in our society and we already produce new forms of it, this is evidence that technology as part of a general education is not needed. But one can also see, conversely, that it is amazing that so many people go into such professions when there is no rational basis for their relationship to it other than as an amateur pursuit or a hobby. Ultimately, it is probably the ubiquity of technology and the fundamental interest of many people in it, which compensates for the gap that exists in general education. That this is so, must be seen by society as a whole as very positive. However, one can not assume that this is an optimal situation that will "always" stay that way. In addition, difficulties are to be expected, if shifts take place in this informal structure of general interest in technology among people and basic requirements for courses in technical training and study.

An example of such a shift has indeed been detectable since the onset of computerization, as there has been a decrease in adolescent manual technical skills which is accompanied by a persistent complication, namely the increasing complexity of technology in modern life. Here again we have the example of the bicycle: 20 years ago all the mechanical components of a bicycle were handled with simple tools, but all the mechanical components have now been optimized for lighter weight and higher performance capabilities, while hydraulic (brake) and pneumatic (damping systems) components have been added, Only very technology-ambitious bike owners who have the necessary special tools and keep in contact with these advances are able to keep their bikes repaired. The vast majority of owners are now limited largely to cleaning and leaving its servicing to an expert. Similarly this is the situation with the car: some car owners do not know where the battery is mounted if it needs to be replaced. For such tasks (which used to take a matter of 10 minutes max.) now a garage is urgently needed, as the car has become a rolling computer that requires an appropriate setup for such a basic procedure to take place.

The progressive enlargement of the gap between the basic technical skills of young people and current technical requirements appears more likely to grow given the place of technology in education, as the technical professions must keep pace with progress. This concerns, first of all, the occupations in which problems increasingly arise when simple manual skills are absent, as well as the fact that among the young the technical basis for understanding them is missing. (Opening quotation from the Continental instructor). But even in the tertiary sector the increasing difficulty of finding young engineering talent suggests that this can not only be explained demographically. This is fatal in view of these programs already having traditionally high dropout rates. Here one also encounters, alongside the progressive distancing from technology ongoing in life, an image problem: why should you get involved in a difficult and laborious path across a previously unknown terrain, if it ultimately results in entering a profession in which you are faced not only with the persistent need to keep up with technological advances, but for which you are paid only average earnings and have no special social status?

But even beyond the professional world, increasing problems are pointed to by the continuing gaps in technology's role in general education. This is particularly evident in IT technology, as this progresses dynamically and,has now reached all other central areas of human life. The fact that the "average Joe" is not willing (and never was) to deepen his or her engagement with technology beyond using it has been apparent ever since instructions for VCRs were provided, or even longer. Equally, manufacturers who continually introduce new, more complex technologies have always been able to do this as long as they are easy and safe to use and customers are happy with that. The world famous IT business, Apple, owes its present status ultimately to its comprehensive user-orientation, whereby it is not the maximum use of technical possibilities that is important, but their adaptive and user-friendly provision. However, we now use equipment and technology that has enriched the most important areas of our lives (information, communication, finance, trade, professional, security, leisure, entertainment, ...), but which we hardly know anything about concerning how they work. Even the usable options are only partially known and we do not have the slightest idea of the associated hidden possibilities. An ordinary smartphone exceeds the technical capabilities of a mainframe computer from the 1980s by many times, and is a global network with a wealth of programs, whose existence and source code is understood only by their developers. Taking security-related issues alone regarding technology use, the current state of education among adolescents is nowhere near adequate when dealing with, for example, computer viruses, Trojans, Botwebs, password protection, phishing, internet trading subscriptions and in-app sales as well as the protection of privacy on social media. These topics are - in view of the dynamics of digital development - only snapshots, because changes in technology expand the spectrum of its exploitation and abuse. Indeed even with good will and great effort in the current education system it is not possible to react with a conventional curriculum, because by the time a relevant curriculum appears (1-2 years), it is then hopelessly outdated. This also affects conventional subject-specific teacher training, because these issues can not be isolated to individual subjects as they require both a tremendous amount of expertise and a lifelong developmental attitude.

The fact that the looming problems here outlined have at least been recognized is something that can be seen over the past five years through the activities of the German MINT, an acronym for "Mathematik-Informatik-Naturwissenschaft und Technik" (Mathematics, Informatics, Natural science and Technology) which was established as a counterpart to the Anglo-American STEM, referring to science, technology, engineering and mathematics. Here the interdisciplinary nature of technology is framed and given a space to develop, while exploring their points of connection with general education. In 2012, for example, a national

STEM forum of numerous foundations, academic institutions, professional associations and university alliances was established, the "mission statement" of which determined that the knowledge of mathematical and scientific-technical relationships is essential for a fundamental openness to scientific and technological developments, and which provides the basis for a social discourse on scientific and technical problems allowing responsible roles to be developed in dealing with global challenges. The field of technology was first identified here as a much-needed supplement to the generally representative overall framework of education, as this was not a matter of a subject or individual aspects, but was comprised of themes and subjects that concerned an area comprehensively related to all areas of education Its development focus was advised as a necessary part of schools and curricula, but in particular teacher training and underlying academic institutions and systems.

By contrast, our education system has so far remained relatively unaffected. An understanding that an engineering education cannot "suddenly" begin to function as part of a general education and in this regard ensure a viable responsiveness has only recently been made. A subject with the topic of technology would take longer to establish, and perhaps only in the smaller German states, and then almost exclusively in secondary schools. Here they could deliver instructional content from a heterogeneous curricular perspective, even though the time available would be rather narrow, and a technology-oriented subject beyond teaching and working classes could then be established in general education. This subject would be supported by a community of science teachers which in particular would address the issue of teacher training colleges.

At some grammar schools (such as one in Baden-Württemberg in 2007/08) departments with the label "Naturwissenschaft und Technik" (NwT) have been introduced. This can either be taken as a foray into Humboldtian secondary education, or as a compromise made by schools towards lessening the degree to which topics of a technical significance are ignored. The introduction of another interdisciplinary, technology-oriented profile subject "Informatics-mathematics-physics" (in short: IMP) has seen Baden-Württemberg clearly position itself in this area as an innovation driver. It is offered in grades 8 to 10 in high schools and community schools and then as an alternative to the existing NwT subject profile. IMP is centrally focused on computer science and - based on this – an emphasis on mathematics and physics is included. The linking of science and technology manifested in both NwT and IMP can be seen either as an understanding of the interdisciplinary claim made by this "subject", or as a concession to the need for a strong science presence in schools, which is retained as it was in any case, with technology added as a quasi-gesture. But this has to be seen as an initial positive step, as the NwT curriculum is extensively biased towards technology, is offered, in Baden-Württemberg for example, in all schools in the 11th and 12th/G7 (13./G8) and counts also as part of graduation from high school. In the 6th and 7th classes, a pilot scheme is being run. To date, NwT is mostly taught by technically retrained teachers in physics, chemistry, biology, computer science and geography, with an emphasis in the latter on physical geography, until 2012, after which the introduction of the subject in teacher training college will have been established .The first trainees will graduate from Baden-Württemberg in 2016.

In relation to the whole scope of general education regarding subjects and grades – including the current developments in Baden-Württemberg - technology will play a small, but growing role, while its presence in elementary and primary education is so far the exception. This is strange, because it has been proven many times that this is the most important way for it to be provided within school education. Regardless of the ongoing boom in technology-related toys (Fischer, Lego, ...) children gladly receive instruction in handicrafts and hobbies, with the result that the natural interest in technology demonstrated by many boys and girls goes unnoticed. The fact that engineers (who are mostly male) even in the 21st century come from families with an engineering background, means that the probability of a girl from a non-engineering household pursuing a technical profession is extremely low.

Education policy could change something about this situation, but this is largely shaped and designed by people who do not have an engineering background. This is not to accuse people of technophobia or of being anti-technology, but it is difficult for people without the appropriate technical skills to "empathize" in a complex, deeper and innovative way about the needs of our existing education system. We do not need "a little electrical engineering here," "a little computer science there" and "a little metal engineering over there". Technology is currently already so comprehensive that its particulars should not just be part of sections of other disciplines, and its dynamism be dissipated by letting its supposed unmanageability grow. In the spirit of Klafki this can only be overcome by a categorical understanding of education, one that emphasizes the link between its material and formal aspects. Applied to technology, this means that it should not just be handled as a specific or integrated subject, but that it should be a specialized topic.

5 Consequences of failure in technology-related education

Given the current exclusion of technology from most of our areas of education and the lack of any visible development in this key educational aspect in our present or future society, there are a number of consequences for the individual and for society:

For the individual, a person's life will be characterized by comprehensive access to technology, not as a designer, but as its user. Technology is there - depending on your money – to be purchased, and - depending on your intentions and requirements – to be used, and its ongoing development will be seen from a user's perspective. Technical development is connected with positive expectations (better cars, better medication, environmental technologies, ...) but also negative ones (dangerous weapons, environmental degradation, ...). The influence on technology and its development will be confined to experts and will be perceived as increasingly remote, difficult, and incomprehensible. This combination of a failure to understand its workings and the delegation of its development on the one hand, and great interest and the high level of importance attached to it on the other hand, has to be viewed sceptically from an educational perspective. The coming of age of a person depends upon his or her understanding of the things he or she decides in favour of. This may be the case in Western societies today regarding political and social aspects (causes), however, as far as technology is concerned this is not true at all. Therefore, currently all social and political processes associated with technology are determined to a significant extent by irrationality.

There are enough examples, but one such as the nuclear power debate has run intensively for decades, but is mostly dominated by emotions rather than facts. That the recycling of radioactive waste is technically impossible, the concept of "disposal" used here is ultimately a lie, but has been repeatedly represented politically only because of a lack of technical understanding among the population. Similarly, currently with the ongoing "data movement" if internet users could understand the possibilities for current and especially future abuse of their "private data" that the technology already allows, people would be much more careful with social networks and other "datankraken". Even if people have such a thing as personal settings, they often lack a concrete rational basis and thus a mature foundation. However, since this is true for most in society it is currently hardly perceived as a problem.

The review of technology and its broad implementation is therefore the responsibility of people, the majority of whom will not or only conditionally understand what is problematic both in terms of the opportunities and the risks of technology. The government-sponsored environmental protection mechanism, the “Wärmedämm-Verbundsysteme” (WDVS), a thermal insulation system, is an example of what the consequences may be of a comprehensive failure to understand technology. The opposite of a traditional technology, WDVS obtains minimal gain in terms of preserving heating energy in proportion to the necessary production costs, not to mention the subsequent expense of the disposal of vast amounts of polystyrene plates. WDVS are also built on questionable physics, as they prevent moisture diffusion through the walls of houses and provoke, due to the thermal action, plaster damage from algae, while also representing a significantly increased fire hazard. That WDVS are installed just as before, is thus only to favor the construction industry and based on the technical ignorance of politicians and consumers. Those in our society who understand and shape technology, the engineers, do not win in this constellation of power, because they are involved in the decision-making processes only to an extent that is opportune for the respective protagonists. Thus, not only are they denied a high-level political role, but any sustained appreciation of their value is absent because they are ignored or ridiculed as technocrats, hobbyists, DIY enthusiasts and simply craftsmen or nerds, and thus we know that the key routes to profits and income will be handled by others. In such a society, technical skills are not accepted as a form of education, and its absence does not even register as a lack of education. Where the patents come from that secure large companies their continued market positions, or who it is who ensures that productivity in Germany remains in its top position, or who ensures that our infrastructure and households repeatedly have access to the latest equipment and facilities for our use, comfort and safety, appears to be irrelevant. This is, and will remain, the case and the means of becoming an engineer will be beside the point, because it is believed that they "somehow always existed and will always be there". Given the fact of globalization and the world-wide acknowledged “war of talents” this attitude will be increasingly naive. This raises the question of how long our society can compensate for this imbalance, both politically as well as economically.

6 How do we get technology taught in schools?

Overall, based on the current state of technology teaching, overall reform is urgently required in all aspects of our education system, from kindergarten to the upper level of secondary schools. Approaches such as NwT or IMP, which are implemented at the high-school level, are very important, but only address the higher education level and focus on it largely in a scientific and mathematical context. As explained earlier, technology is one of the key engines of human development, therefore, there is hardly an aspect of life or of an education that knowledge of technology would not be of significance to. Even the preponderance of political and social history could not be achieved without the implementation of technology. Similarly, it presents itself in geography; for how could you discover, develop or measure the world without technology? How would human infrastructure, be it residential or commercial premises, be feasible without technology? Another example is sport. Human movements are laws with comprehensive technical implications (Biomechanics), and it is hardly a sport without its reliance on technical premises, tools or measuring equipment necessary not least in relation to ethical issues regarding doping, which itself is nothing more than a perverse use of technology applied to human performance.

Technology should thus not just be implemented in the sixth form and not just in a scientific and mathematical context as it is in our education, but should be as "ubiquitous" as it is in our lives. For this purpose, each current school subject should openly deal with technology and work in its respective educational aspect, based on what aspects of technology are important for its purpose,and find how they can be implemented didactically and methodically, and in particular (due to the high dynamism of technology) how the particular subject may continue to keep itself updated and relevant. Beginning in elementary education, technology must establish itself up to the secondary I and II schools as a continuing part of the curriculum. In the first part of the secondary level it should be an integrated subject in the basic fields of metalwork, electrical engineering, construction and information technology, while in the second part it should be both an integrative subject below the upper secondary level and in the form of independent branches (as with maths and science branches) in high school.

Given the need for such high standards over our entire system of general education and the development of the underlying curriculum as well as teacher education, it is clear that an enormous effort would be required by many protagonists over a long period along with major financial investment. Whether or to what extent the current implementation of NwT in high schools can be seen as part of such a departure is difficult to answer, because this concerns the future direction of education policy.

All those who do not want to just wait to see if there is a reaction in education policy or wish to prompt such reactions by encouraging the appropriate commitment, there are ways to act immediately. Although the current curricula hardly include technology among its general subjects they rarely completely exclude them. Thus every teacher can accentuate the role of technology in his or her specific subject. This topic becomes more complex and compelling when another subject is involved, for example, through a technology accented project. In order not to fall into dilettantism here, engineers should also be involved. These are usually easy to find locally, either directly in cooperation with enthusiastic companies or their respective chambers of commerce or confederations. Equally fruitful are possible collaborations with vocational training centers or universities. This can already provide the basis for launching an "open technology" school, while the next steps would be a comprehensive implementation of technological emphases in all subjects and at all grade levels to establish a corresponding anchor in school quality management. If the schools do not take the lead here the economy can be active by encouraging and supporting the appropriate processes in regional schools. Where this has been successfully established, qualified consultants in Technical Education can go to the schools and supervise them regarding forming networks, use of materials, media, among other resources that are available, and to establish prizes for schools and teachers and advertise for students, etc.

Given the traditional and mainly technology averse nature of our general education system, the approaches proposed here are certainly only small steps, which can only be instigated regionally. Whether and in what form responses will follow at the curricular level in the coming years remains questionable. Nevertheless, presented here is a wish to detail existing shortcomings and in particular to examine their consequences, and provide other facts to show that technology is not just something related to the professional world which we enter as adolescents after our general education is completed but to show what it "can be." It necessarily belongs to and must be an essential part of our general education and this is possible without denigrating the importance of other subjects or putting their existence and their significance in question. Only if we succeed will our society remain mature in the face of its increasing technological advances, and not just in the hope of keeping up with technological progress. We must educate ourselves so that we can shape that progress decisively and capitalize on its opportunities and confidently confront its risks.

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