Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025
ASEE
Paper ID #47584

A Review of Basic Factors on How to Recruit Young Engineers

Prof. Martin Karl Fislake, University of Koblenz

Martin Fislake was trained as a mechanic during an apprenticeship in Germany before he got his first and second teacher exam as a vocational teacher for mechanical engineering in 1993. Following that he was hired at the University of Koblenz and is since then continuously working as researcher and full-time lecturer and head of the technology education department where he teaches primary and lower secondary student teachers. In 2001 he received his doctoral in engineering education, higher education didactics and educational economics. 2024 he was appointed professor in his field. In addition, he operates a technology-oriented summer school for children and youth as an education and research project. He writes and presents widely on issues of technology education with a focus on educational robotics and his out of school project technikcamps.

A Review of Basic Factors on How to Recruit Young Engineers

Abstract

Known as the land of poets, thinkers and engineers Germany nowadays is threatened by an increasing shortage of skilled workers in engineering fields which could have serious consequences for the innovative capacity of science, business and economics.

Consequently, the declared aim of current activities by various initiatives and institutions is therefore to promote a sustained interest in technical careers and to increase the number of persons who acquire appropriate qualifications. Although many of these initiatives have already been working on this for two decades or more, the offers to promote technical career choices have not yet been sufficient to really prevent a shortage of academically trained engineers.

To discuss this challenge, this paper first describes the today's situation of recruiting young talents for engineering together with interdependencies and determinants of the individual decision-making process that has to be considered.

Aspects and contexts of the problem are then explained in order to distinguish between short term and sustainable solutions. For that, it presents details of technology socialization as an important but underrated key factor, issues from individual educational economics decisions and findings about the importance of an early and continuous offer of technology education.

As a result, interest in technology should be stimulated and maintained primarily through continuous, didactically effective support of young talents, enriched by positive key experiences. This support must begin in early childhood and continue through all phases of education.

Introduction

As in other countries, the current shortage of qualified young professionals in STEM (Science, Technology, Engineering and Mathematics) related fields will nowadays significantly impact Germany's economic growth and the quality of life of its citizens unless decisive action is taken today to counteract this trend based on reliable information.

To describe the problem in details, the latest labor market report of the IW-institute (translated by author: Institute of Economics in Germany) in Cologne, Germany (www.iwkoeln.de) for example vividly illustrates the enormous scale of the shortage of some 200,000 STEM specialists, including 77.700 engineers, in 2024. At the same time studies by the VDI (translated by author: Association of German Engineers) and IW-institute estimate an economic loss of up to 13.4 billion EUROs annually, as companies have had to turn down orders due to a lack of available skilled workers at all levels (according to Verein Deutscher Ingenieure [1]).

Unfortunately, these analyses have almost forgotten about the sociological conditions as decision factors for students, as Pfennig [2] states. Fislake [3] and Heine [4] add that these developments are merely a result of the cumulative effect of individual decisions. As a result, despite interest, talent, and a positive self-image of expected technical skills, there is a lack of enthusiasm for STEM careers and studies.

To address the problem, policymakers, business, academia and civil society are attempting to address the STEM skills gap through a variety of activities to promote sustained interest in technical careers and to increase the number of people with the appropriate qualifications, such as the MINT Forum (MINT is an acronym for *Mathematics, Informatics, Natural Sciences and Technology*. It is the German equivalent to STEM) announces Heine [4]. At the beginning a large number of student labs, student research centers (according to Haupt et al. [6] and Haupt [7]) and makerspaces were quickly established in Germany as Pfenning [2] declares; model projects were launched, evaluated and disseminated. In the wake of the so-called PISA shock (PISA is an acronym for *Program for International Student Assessment*, initiated by the OECD), realization that the quality of STEM education in Germany was not up to international standards also played a role (according to Prenzel et al. [8], OECD [9].

However, between 2000 and 2010, there has been a boom in research on this topic in order to understand this task and to avoid "simple actionism", as Projektgruppe [10] describes the situation. Most studies today merely deal with the labor market problem itself at one hand or list any simple recommendations at the other. As a result, quite a few activities are based on so-called key experiences, short-term effects of only single intervention, which are much easier to prove with empirical methods than measuring long-term effects. However, they also ignore the importance of long-term effects like socialization or habitus acquisition and that the probability of prediction decreases with increasing time between cause and effect.

According to Pfennig, from a sociological point of view, all of this support for STEM education could be interpreted as a critique of STEM education in schools with its frequent lack of technology education. The semi-professional equipment in out of school student laboratories and science centers, the professional supervision, the project character and above all the opportunity for independent design, research and experimentation with new pedagogical concepts such as research-oriented learning (according to OECD [9] and Projektgruppe [10]) provide a strong contrast the conventional school setting.

Related Work

One of the attempts to compare individual attitudes and determinants for a pro-MINT career decision was conducted by Heine [4]. The primary aim of the study was to identify the main reasons why school graduates choose engineering as a university subjects. A further aim was to evaluate the results from a political and action-oriented perspective in order to identify possible interventions in favor of (re)increasing the choice of engineering and science subjects.

As a result, three central areas for political action can be distinguished: Increasing the

- general willingness to study
- decision in favor of engineering and natural sciences
- study success rate

The authors recommend that some of the necessary measures can be implemented in the relatively short term, while others can be tackled in the short term but the desired effects will only be achieved in the medium or even long term.

Another attempt, conducted by acatech [12], focuses on the most important initial findings and the conclusions from empirical surveys of 3,500 students at the school level (with and without technology instruction), around 6,500 students at the university level (including a control group) and a survey of members of eight engineering and natural science associations (approx. 3,200 respondents).

A comparison of these expectations and experiences revealed considerable discrepancies. High expectations of extrinsic and intrinsic motivations are often contrasted with sobering experiences from their studies and careers. Where expectations and experiences do not match, didactics is required, because it poses the central question of how to impart adequately knowledge to interested parties.

Another result summarizes the individual technology socialization as one of the most important factors for a pro engineering decision and therefore emphasizes the ever more important role of institutional technology education in schools for a successful technology socialization. The influence of early childhood play and partial support in school and kindergarten has also been researched by Ziefle et al. [13] and acatech [14].

The first Barometer study was followed later by a follow-up series, from which the annual STEM Young Talent Barometer emerged. The results still confirm an urgent need for STEM education activities in schools in order to counteract the fact that STEM subjects and jobs are still not very attractive for many young people.

Determinants and Interdependencies

Recruiting young engineers is a complex challenge that must take into account numerous determinants and interdependencies, ranging from individual talents to childhood toys, interests, and family environment. Choice of school subjects, social media, career counseling, and feedback from the business community also play a critical role, all of which can contribute to the decision to enter STEM fields.

In addition, never before has there been such a great gap between the daily use of technology and the willingness of young people to choose a corresponding course of study. Use and interest have become decoupled, which is not particularly surprising because of the extensive technologization of day-to-day life and the economy. To compare it Figure 1 shows that technically interested school students and university students have played during childhood and adolescence much more frequently and more intensively with technical toys than today's general school population.

acatech [12] also confirms that school students interested in technology do not necessarily have to have better school grades than average. In political studies, English and particularly German, the grades of these students at school level tend to be below average. In physics and mathematics or – if offered – in technology classes, these students at school level generally perform better than the class average. In light of these findings, it could prove counterproductive for the career image of engineers that the media often portrays them as Germany's top performers.

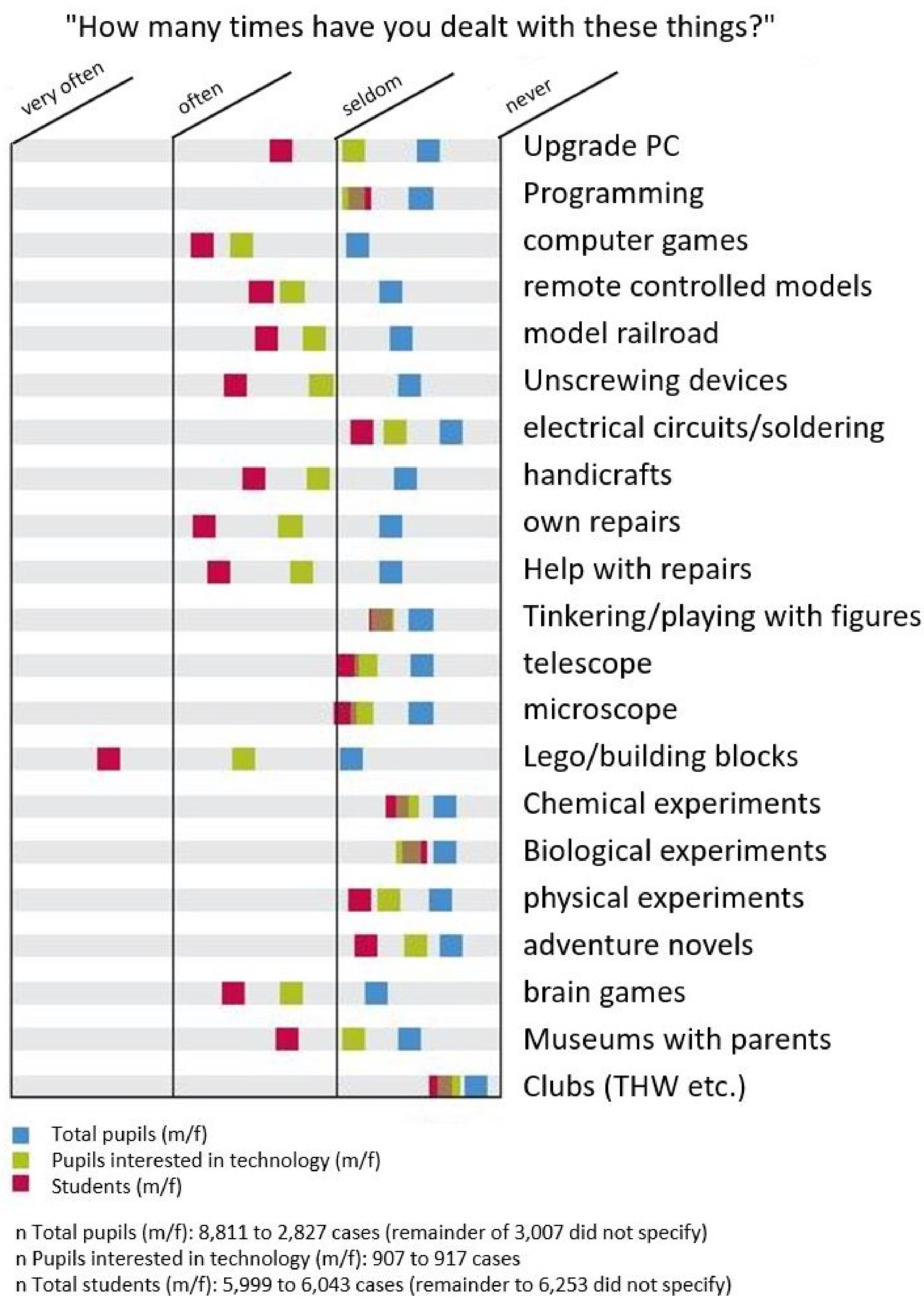

Figure 1: Technology and scientific play references of pupils in childhood compared to students at university level (according to acatech [12]).

Technology Socialization

That positive key experiences made at home, in museums, on events or in schools still influence the generation of interest towards technology was another finding from the study by acatech [12], concluding that early technical socialization is one of the decisive factors for a later orientation towards STEM jobs. Socialization theories deal with the interplay of individual self-discovery through the identification of abilities and talents, social roles, such as professions, as well as the internalization of values and norms within the framework of institutional ties such as parental home, school, university, training company, circle of friends, etc.

Pre-occupational socialization research is process-oriented, less retrospective than life course research, and looks for the connections between socialization trajectories, habitus acquisition, and career entry into the labor market. This kind of life-span approaches explained by van Tuijl and van der Molen [15] follow vocational psychology and emphasizes career development as a lifelong process and childhood as a formative period for it. According to Krüger [16], the approach asks about the socializing achievements of the institutionally multifaceted transition paths from school to work in a lengthening youth phase.

Ivemark [17] further depicts habitus acquisition as a product of socialization, which can be significantly shaped largely in the family, but also by the immediate social environment, even at a young age. More concrete Prenzel [8] emphasizes it as a matter of creating basic opportunities for experiences that are as comparable as possible for all children, especially those from educationally disadvantaged backgrounds.

This process refers directly to the science of familiarizing children and young people with technology at an early age in order to develop their interest and motivation to engage with technology. It is called internalization and is initially triggered by parents, kindergarten and schools. Highlighted by Papadakis [18] early childhood (from birth to age eight) is a crucial period for children's development. They see teaching STEM in childhood education settings as one of the most prevalent ways to prepare students as future engineers. Pfenning [19] and Ziefle et al. [13] extend this approach by suggesting that successful engagement with technical topics requires a combination of interest, motivational dispositions, and cognitive abilities. It is not enough that someone wants something; he must also be able to do it.

Consequently, Pfenning et al. [19] further extends this approach to technology education. Figure 2 illustrates the relationships between technology education, technical socialization, and technical professions as a social institution in which knowledge, application, and competence converge. It indicates that this is a self-reinforcing process, i.e., outcomes of primary technology socialization can be reinforced by technology education or occupational experiences. Therefore, it is important that the various actions in the different areas of activity are coordinated.

It is precisely at this point that young people's access to STEM is made possible. Providing them with the right opportunities to participate in technology and the technical sciences, as well as career guidance, and helping them to identify and develop their talents, plays an important role.

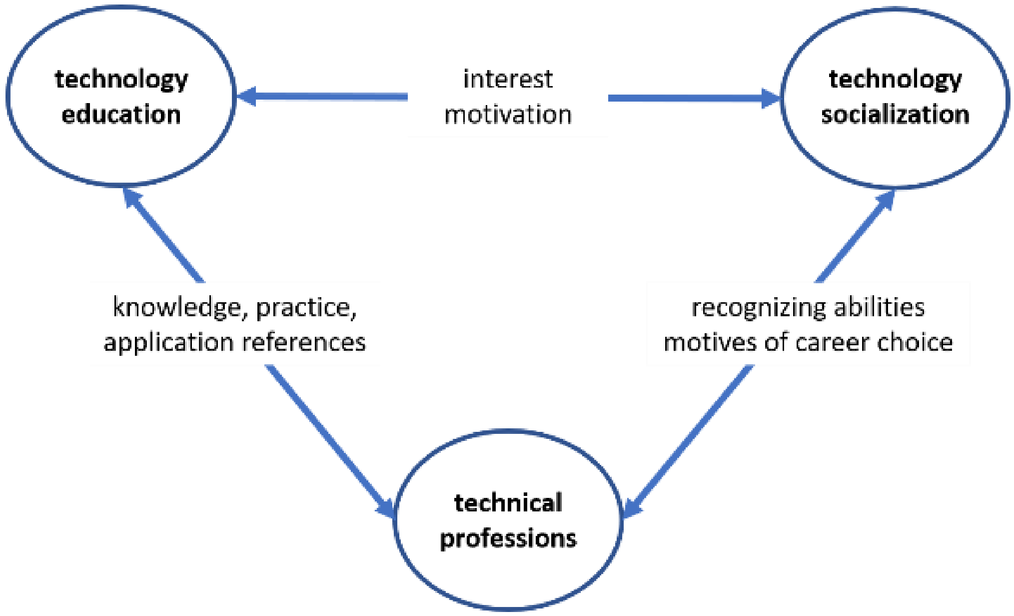

Figure 2: Interdependencies of technology education, in accordance to Pfenning et al. [19].

Nevertheless, technology socialization has to be considered as an important condition for choosing a corresponding STEM profession. On the one hand, it helps to identify individual abilities and skills in technology, while, on the other hand, it contributes to social support for the corresponding career choice and to the positive perception of these jobs (prestige).

Even if this imprinting does not guarantee a continuous interest in technology, acatech [12] continues, it is important to distinguish that they are technology-friendly like other generations, only the way of looking at technology has changed. acatech [12] goes on to say that young individuals nowadays are changing from makers to predominantly unreflective users and that technically gifted and interested children and young people need help in spite of the many new support programs and projects. However, technology socialization is at the same time increasingly losing scope and diversity in the reality of our children's lives.

Schools

From the perspective of school students promoting technology knowledge does little to stimulate an individual interest in technology or to develop their own corresponding gifts. For one thing, technology lessons are not offered universally, and above all not continuously, in German schools. This is a mistake, as acatech [12] concludes. The results of the Barometer-study also reveal in contrast that good technology instructions in school demonstrably can improve individual technology interest when the curriculum includes technical topics and the equipment and didactic structure of technology education are in a good condition.

Career information is also considered as a task of the schools. All target groups view this career information as largely negative, while internships in contrast are more popular as they enable youth to form their own impressions of the career landscape and compare the requirements of a particular career with their own abilities. The internship should ideally be highly varied in order to reflect accurately the wide range of technical careers as well as the corresponding motivational situation of school and university students. As second, schools can play a central role for delivering information about STEM and particularly technology because school students identify schools as one of the most important sources.

Another important trend may be that too much attention is being accorded to the development of talents as a learning objective and too little to general interest in technology. Raufuß [20] describes the development of a technician from school onwards in a very drastic way: “Anyone who as a child or adolescent has difficulties coping emotionally and linguistically with social problems, for example, and who at the same time has a positive basic attitude towards technology devices and mathematics, will initially feel relieved in physics lessons, for example” (translated by author). During the last three years at school (grade 10 to 13) the focus is then on the subject area that "means that social skills are dispensable" (translated by author) and a move away from languages, history and mathematics. From now on, there is a process of adaptation to the social norms and views of the specialist community of "technology", with which he ultimately identifies.

Consequently, the positive and negative social consequences and economic utility of technology should be communicated more intensively. However, these are precisely the topics that can awaken more interest and contribute to greater awareness of technical issues, particularly among girls. After all, it is in school that young people not only acquire factual knowledge, but also form their ideas about technology and the careers associated with it.

Gender

Young people willing to study experience themselves as autonomous individuals. This has consequences, particularly for women. Female school students do not regard a low proportion of women in a preferred course of study as a major obstacle to choosing that course. Thus, in this respect, the many initiatives to increase the motivation of girls and women have already had a positive impact. Although, the Barometer study provides further indications that female school students and university students are still confronted with disadvantages, i.e. external obstacles, that make it difficult for them to realize their interests. Additional efforts are needed to motivate talented and interested young women to choose technical studies and careers.

This objective is obstructed at first by structural barriers: the comparison of individual expectations and structurally/institutionally communicated experiences under everyday study and career conditions indicates a high frustration potential due to real disadvantages, particularly for women. Many made negative experiences in their studies and career and were subject to both individual and structural discrimination. This includes not least lower wages, but also a greater risk of unemployment and dropping out of the workforce due to the inability to reconcile work and family.

Beside these finding the acatech study [12] demonstrates that social prejudices like “girls aren’t as interested in technology as boys” or “most boys understand technology better than girls” (translated by author) are still widespread. In addition (in the comparison between samples of female and male students at school level and university students as well as the control groups) are disproportionately present in the male representatives of these academic disciplines.

Motives for choosing a subject

An analysis of the reasons for choosing a course of study or a career makes one thing clear: young people interested in STEM subjects are not a homogeneous mass, but can be divided into different groups with different motivations, which must be taken into account simultaneously and, if necessary, supported in a differentiated manner.

This includes both committed technology enthusiasts and externally motivated rationalists for whom a secure job, high income, and opportunities for advancement are of primary importance. These two motivations require different strategies to support and nurture individual interest.

Image

In contrast to the impression of a negative widespread image of the engineering profession according to acatech [12], these surveys reveal that young people have more of a positive conception of technology jobs. Technology professions are associated with such positive attributes as “modern”, “progressive” and “useful”. In addition, the contribution of technical research to the development of humanity is viewed as positive. Economically related attributes such as “creating jobs” and “serving consumption” also find a high positive resonance.

However, in spite of the predominantly positive image of these professions, technology careers and courses of study are seldom chosen, even by students at school level with an exceptional interest and high qualification in this direction. An interest in technology by itself is not enough to prompt young people to take up a career in STEM. Less than 50 percent of the existing potential pool of students with an interest in technology or natural sciences was utilized as acatech [12] points out.

This shows the problematic development that the expectations of such a job hardly match the characteristics of the ideal profession and those who decide against a technology degree despite their exceptional talent are convinced that these courses are complex, demanding and risky, while those who choose these courses tend to underestimate the requirements.

Consulting

Although the trend in Germany is to advertise jobs, apprenticeships and courses of study like a product as can be seen in Figure 3 with open house days, career choice fairs and career days, school students today rely more on their own impressions and experiences than on external information about careers. In contrast, internships, along with career information from the internet, are valued highly for gaining personal experience or obtaining specific information.

Young people use this information as a basis for their own choice of studies, especially when extrinsic and intrinsic motives are in conflict with each other. However, the perceived direct influence of social trends on the choice of study are rather low.

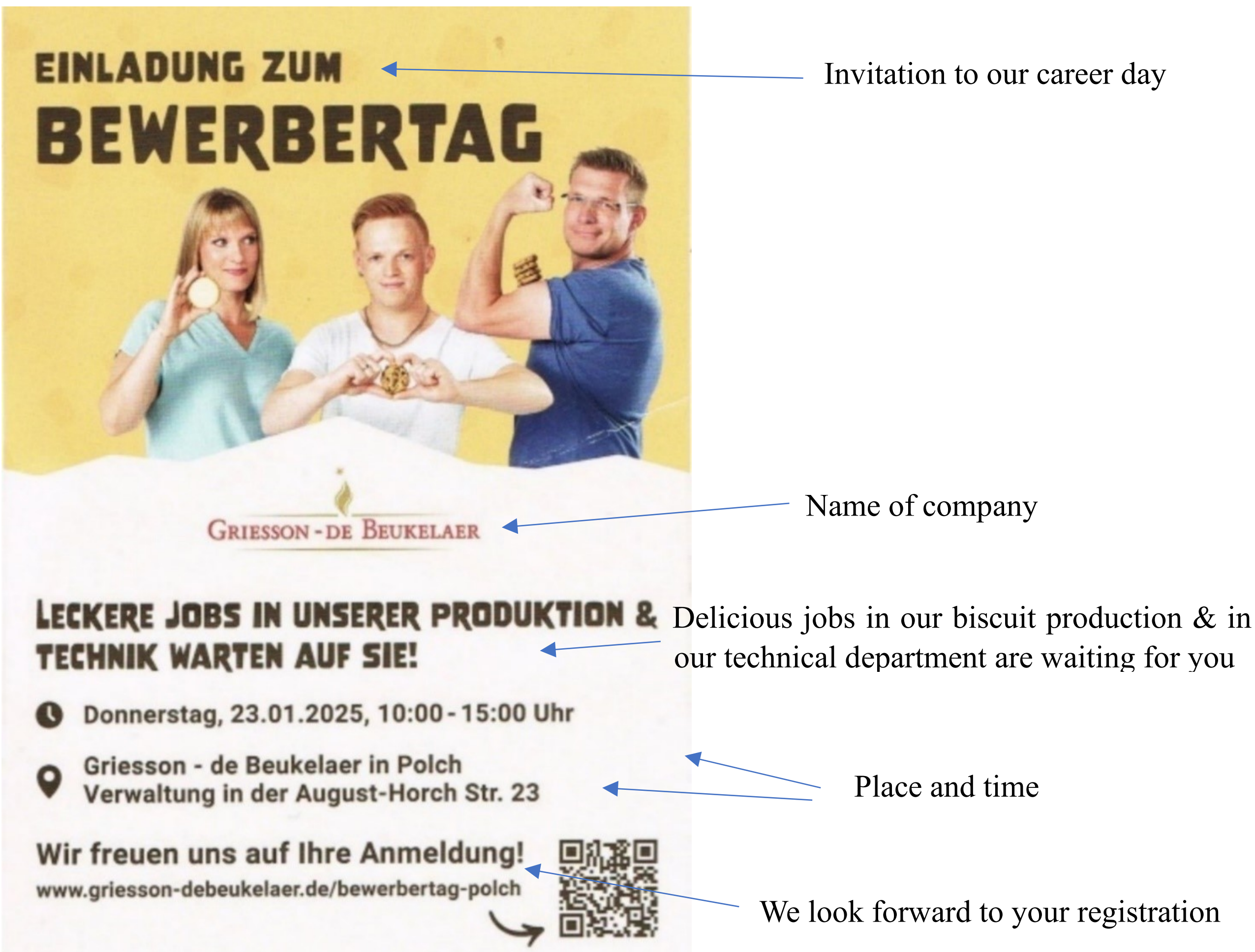

Figure 3: Advertising for a career day (© Griesson - de Beukelaer 2025), translated by author.

The effect is more latent and not on the immediate conscious level, while at the same time they observe the developments on the labor market reported in the media and the lower their social background, the more strongly they orient their choice of studies and career to it.

Social background

With regard to social background, it can be stated that there is a significant correlation between the level of education and choice of study throughout the period under investigation from 1985-2005. While this trend has even intensified for subject groups such as cultural studies, social sciences and natural sciences at the same time, an effect occurred in the engineering sciences that is only significant for classic "upwardly mobile subjects" as Georg [21] states.

This means that the likelihood of people with a low level of education opting to study engineering increases with the level of career prospects. In other words, as those with a low level of education make their choice of field of study dependent on the labor market situation, the social selection of first-year students is overlaid by economic effects.

According to Georg [21] specifically, in 1985 after a period of consistently low unemployment rates among engineers, the choice of engineering was the least dependent on social background, while in the 1990s social selection increased sharply with unemployment. As a result of an improved labor market situation at the beginning of the 2000s, this dependence on social background decreased again and is now relatively neutral in terms of social classes.

Economic based decisions

Based on findings of the studies of the Higher Education Information System (HIS) the Barometer study, conducted by acatech [12], indicate a variety of reasons that lie behind the choice of a course of study on the part of different groups. Thus, there are school graduates who choose their course of study more for

- materialistic reasons
- intrinsic reasons
- mix these extrinsic and intrinsic reasons

While materialistic reasons include the state of the job market, expected income, opportunities for advancement, expected job security etc., many graduates associate these expectations with a career in a technical profession. Others choose their courses for intrinsic reasons like realizing their talents, balancing between work and life, pleasure in the work, self-realization in the career, while another group mix these extrinsic and intrinsic motives and make their decision on the basis of complex situational reasons.

Another approach to explain the choice of study more in detail follows the rate-of-return approach in education economics. First of all, it is based on three principles:

- Knowledge, skills and abilities acquired in the education system leads to an increase in value-creating potency.
- This potential must be significantly greater “than that which the workforce would have had if they had not worked in the education system but in the economy during the same period” (according to Maier [22]).
- Labor power is a factor like any other, even if this conveys the dilemma inherent in neoclassical theory (according to Maier [22]).

From the individual’s perspective, this leads to the decision problem of tying up capital through investment. Accordingly, an investment in education must always be evaluated with the goal of achieving a higher rate of return than alternative acquisition options. The return on additional investment in education must be greater than or equal to the return on alternative investments.

However, the calculation is getting more difficult by the fact that the amount of an individual's human capital, in the form of accumulated work, depends not only on their intelligence and abilities, but is also determined by their personal origin and social status. For where education is often a consumer good for a particular section of society, as a kind of “status symbol”, it still serves the working classes to a large extent as a way to develop “detailed skills, which takes place without context and often even in contrast to their all-round development” as Maier [22] explains.

These poles identified by Maier [22] also tend to be reflected in the results of the cyclical motives for choosing a course of study. According to the classification developed by Snow [23], at least an indeterminate proportion of those with a lower educational background can be assigned to the pragmatic, career-oriented, calculating ideal type of the “homo oeconomicus”. Anger concluded [24] it is because the engineering profession is a prototype for social advancement through education. The opportunities for advancement here are least dependent on parental educational background while another indeterminate proportion of the academic’s children belong to the less career-oriented, more intrinsically educationally motivated ideal type of the “homo ludens” (according to Baethge and Teichler [25]) - for whom studying in itself represents a gain.

However, since even objectively determined human capital values are individually interpreted as the basis for study decisions, approaches to calculating attitudes towards studying as shown in Tables 1, 2 and 3, are perfectly permissible in this context and in line with Gries [26]. As a basis for subjective decisions, consumption and investment expenditure was taken into account in the tables and compared with the expected returns. This includes education and reproduction costs, subjectively estimated opportunity costs, the effects of the education system on the individual's state of mind, on the individual's disposition and abilities as well as their presumed effect on the assumed income development.

Table 1: Individual yield rate forecast before the study (according to Fislake [3]).

Before studying	
Costs and income as:	**Purpose of:**
+Internal assignment to the profession	Supposed job description
+Internal assignment to the study program	Idea of studying Cultivated talents
+Expected income	Labor market
+Expected social status	Social background (Academic child/Educational climber), Reputation in society
-Expected study effort	Workload
-Expected opportunity costs	Duration of studies Lost leisure time Individual income opportunities Learning material etc.
Total = Enrollment?	

Such a comparison, in which an attempt is made in a cost-income analysis to “record and compare the characteristic costs and returns relevant to the respective decision situation and to determine the most advantageous alternative ... is a common economic instrument for making economic choices” Rissiek [30] declared. If these specifications are applied to the individual decision situation for or against studying a particular subject, the list shown in Table 1 results.

Tables 1 and 2 also show the costs and income in the left-hand column as individual dispositions to be queried, whereby the costs have a negative sign and the income a positive sign. As a rule, costs and income are functions of the calculation shown in the right-hand column, which, as direct and indirect costs, are subject to different subjective assessments. While the direct costs appear to be relatively assessable from the everyday experience of the individual, the indirect costs, as opportunity costs, can hardly be derived from everyday experience due to their predictive uncertainty and are therefore difficult to foresee.

In contrast to Table 1, the result of which leads to a decision on whether to take up a course of study, Table 2 takes stock of the cost-benefit ratio during a course of study, which is decisive for remaining in the study. This decision is determined, among other things, by the ratio of learning effort/performance evaluation and the emotional states of the decision-maker during the course of study.

Table 2: Individual cost-income calculation during the study program (according to Fislake [3]).

During studies	
Costs and income as:	**Purpose of:**
+Internal assignment to the profession	Actual job description
+Internal assignment to the study program	Everyday study life Cultivated talents
+Expected income	Labor market
+Expected social status	Social background (academic child/educational climber) Reputation in society
+Enthusiasm	Motivation to study (fun)
+Investment in education already made	Duration of studies Lost leisure time Individual income opportunities Learning material etc.
-Actual study effort	Workload Frustration
-Study effort still to be expected	Workload Frustration
-Opportunity costs still to be expected	Duration of studies Lost leisure time Individual income opportunities Learning material etc.
Total = Dropout?	

This is all the more problematic as acatech [12] shows that many positive expectations differ greatly from the actual study experience, for example with regard to the course content, the didactic teaching of the content and the support provided by university staff.

These large and profound differences between expectations and actual experiences of studying engineering ultimately leads to a drop in motivation. Disappointed expectations lead to frustration and, in the event of setbacks during the course of studies, to motivational crises. In the worst case, they can lead to students dropping out of their studies or changing subjects in accordance with the decision model in Table 2. A decisive reason for the large discrepancy between expectations and the reality of studying could be that young people in the career or study orientation phase apparently had few realistic ideas of the actual requirements of an engineering degree course and the job profiles of engineering professions.

While Tables 1 and 2 are based on a decision model according to the neoclassical education theorem, they are set in relation to each other in Table 3. By truncating the constants, such as social origin, the variables adjusted for their units can be released from the earnings rate forecast.

Table 3: Consistency of expectations and actual situation (according to Fislake [3]).

During studies	
Consistency as:	**Purpose of the relationship between:**
+Internal assignment to the profession	Actual job description Initially expected job profile
+Internal assignment to the study program	Actual daily study routine Initial idea of studying
+Expected income	Corrected labor market Initially expected labor market
+Expected social status	Corrected presentation Expected reputation in society
+Enthusiasm	Motivation to study (fun)
-Study effort	Actual and still to be expected Expected workload
-Opportunity costs	Already transacted + still to be expected Expected investment in education
Sum = Statement about consistency	

The result can be calculated individually and as a whole as an indicator of the internal consistency between the evaluations of the original expectations and the actual study reality and thus also as an indicator of satisfaction and thus the probability of retention.

From an educational economics perspective, it can be assumed that the decision to continue studying will only be made if the individual balance sheet calculation is positive and greater than other alternatives.

Exit-process

This all ends up in an exit-process that can be illustrated like shown in Figure 4. From childhood to the end of an engineering degree, a multi-staged exit-process takes place in which the generation of interests described above and socialization have a considerable influence. It starts with the question of the individual talent profile, which can lead to an exit from a technical career at a very early stage. Social background, school performance level, economic considerations and feedback from studies and work are further filters that can either lead to an adjustment or also to an exit.

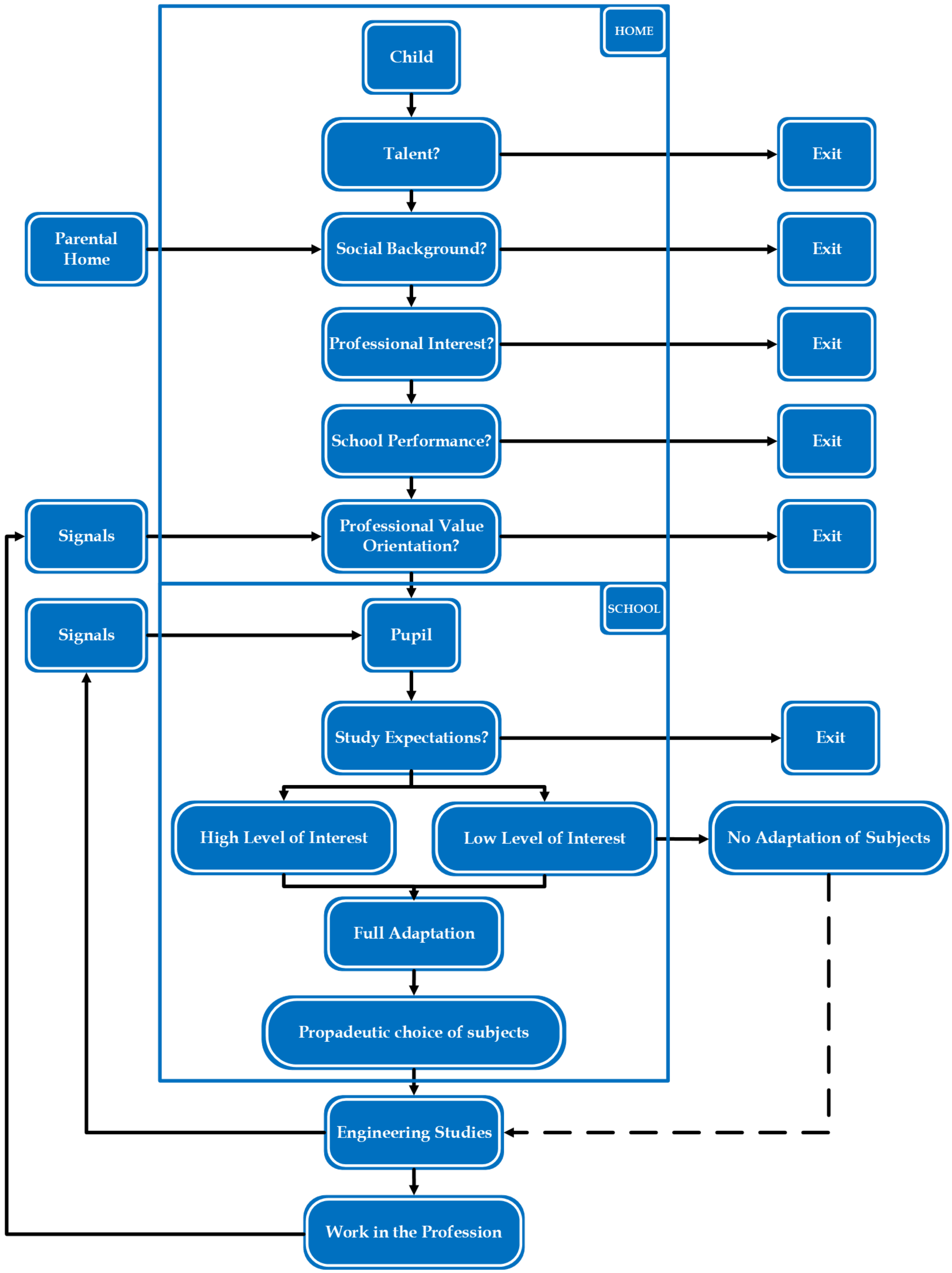

Figure 4: Multi-staged exit process (according to Fislake [3]).

Fislake [3] describes that the process includes exit categories that begins at home at early age and continues at school, where traditionally an educational ideal is conveyed that "sees the actual values in classical humanism and accords the natural sciences, let alone their practical application in technology, a significantly lower rank" (according to Morsch et al. [27]). Due to the lack of a separate school subject, technology is given a one-sided and ultimately false image (according to Bönkost and Oberliesen [28]) and low acceptance as Institut für Demoskopie Allensbach [29] concluded. As a result, Morsch et al [27] resumed, "those who are less 'successful' at grammar school usually choose to study engineering".

Ultimately, the selection mechanism behind the exit-process described above ensures that promotional events such as career days only reach those who remain and further reinforces the motives for the usual choice of subject and manifests the social rank and prestige of engineers in relation to other professions such as doctors, lawyers and scientists.

Conclusions

The presented results confirm discontinuities in technology socialization and between expectations and experiences can be identified at two points. On the one hand, there are discontinuities at the transitions between home, kindergarten and school, when children who have obtained a grounding in technology do not receive corresponding offerings.

The second discontinuity occurs at the transition from secondary school to higher education. While many students want practical exercises that reflect the application character and the expected everyday working life, there is a wide gap between expectations and experiences, partly because the academic requirements are underestimated at the beginning of the degree program. The dominance of theoretical and abstract learning content in the basic course of study is viewed as a burden, and in part as an objectively unjustified form of screening out less suitable students.

First-semester students are confronted with great pressure to perform as well as abstract, mathematics-heavy subject matter. This repels both intrinsically and extrinsically motivated students in equal measure. Respondents also complain of didactic inadequacies in the way knowledge is communicated, which produces experiences of frustration that are reflected in the high rate of university dropouts and negative signals to upcoming generations.

At the same time, it is clear that interest in engineering has to be stimulated and strengthened by means of differentiated educational activities in a much more targeted and broader way than is currently the case in Germany. Young people with a talent and interest in technology receive too little support in spite of a plethora of new support programs and projects. The traditional motivation via building blocks, construction kits and model trains, as well as exploring and repairing technical objects (at home) has decreased among modern youth. No equivalent substitute forms of motivation have yet been identified.

To this end, new ways must be taken in order to respond appropriately to the great difference between the technology socialization of the older and younger generations. Technology must once again be experienced directly in order to cater adequately for the diverse interests and motives of young people.

In this context, institutional technology socialization in the form of technology education in schools, makerspaces or other out of school activities is gaining importance. Above all, interest in technology should stimulated by positive key experiences and maintained through sustained, didactically effective education. Even if these experiences arouse interest in technology, it must be encouraged through appropriate further training courses on technology in order to maintain motivation. This education must begin in early childhood and be pursued consistently throughout all phases of education. The significance of key experiences is also an indication that early education alone is insufficient for maintaining a sustained interest in technology in the long term.

In that task, schools can play an important role in awakening and sustaining young peoples' interest in technology, because technology instructions can significantly increase interest in technologies. In contrast, from the school students' perspective, the current promotion of interest in technology in schools is insufficient. Because of unqualified teachers and inadequate classroom equipment, they describe their current technology lessons as boring and unmotivating.

At the other hand, technology education must be seen as a valuable part of general education, in which young people are trained for life rather than as a short-lived vocational training program. It is a central component of the ability to participate fully in social and political life and a differentiation between economic needs and educating individuals. A good technology education in schools thus increases automatically the likelihood that a technically talented student wants to take up a technical career, and makes it more likely for less interested students to engage with technology. For this reason, institutional technology education in schools is becoming ever more important for successful technology socialization compared to individual technology education at home, the aim being to compensate for the lack of technical experience acquired at home.

But because the promotion of technical abilities in the course of the educational system repeatedly "dries up", phases occur in which interest declines or even disappears entirely. This trend must be counteracted through educational offerings both within and outside schools. In this context, individual actions and events are also important: they stimulate key experiences for students at the school level that provide important momentum for individual interest in technology.

As a result, there are three important factors that increase the probability that young people will develop an interest in technology and discover their individual talents for a technical career:

- early and playful access to technology
- positive key experiences that are experienced as interesting and challenging
- good and continuous technology lessons

This is best done in separate "technology" classes with well-trained teachers and well-equipped rooms. Depending on equipment and staffing, it can also be done in makerspaces or science centers.

References

[1] Verein Deutscher Ingenieure (VDI e.V.) und Institut der Deutschen Wirtschaft (IW e.V). (2024), Ingenieurmonitor 2024/II. Wir gestalten Zukunft. VDI/IW, Köln. https://www.vdi.de/ueber-uns/presse/publikationen/details/vdi-iw-ingenieurmonitor-1-quartal-2024/

[2] Pfenning, U. (2013), Technikbildung und Technikdidaktik – ein soziologischer Über-, Ein- und Ausblick. Journal of Technical Education (JOTED), 1(1), S. 111-131.

[3] Fislake, Martin. (2002), Determinanten und Interdependenzen technischer Bildung aus didaktischer und bildungsökonomischer Sicht: analysiert am Beispiel der technischen Dokumentation im Maschinenbau. Frankfurt am Main: Lang.

[4] Heine, Ch., Egeln, J.; Kerst, Ch., Müller, E., Park, S.-M. (2006), Ingenieur- und Naturwissenschaften: Traumfach oder Albtraum? Eine empirische Analyse der Studienfachwahl. ZEW Wirtschaftsanalysen – Schriftenreihe des ZEW, Band 81.

[5] Anger, Ch., Betz, J., Plünnecke, A. (2024), MINT-Herbstreport 2024 Arbeitsmarktbericht. Institut der deutschen Wirtschaft Köln e. V. https://www.nationalesmintforum.de

[6] Haupt, O., Domjahn, J., Martin, U., Skiebe-Corrette, P., Vorst, S., Zehren, W., Hempelmann, R. (2013), Schülerlabor – Begriffsschärfung und Kategorisierung, MNU 66/6, 324-330.

[7] Haupt, O. J. (2015), In Zahlen und Fakten. Der Stand der Bewegung. In: Lernort Labor (Eds.): Schülerlabor-Atlas 2015. Schülerlabore im deutschsprachigen Raum (34-53). Marktkleeberg: Klett-MINT.

[8] Prenzel, M., Reiss, K. & Hasselhorn, M. (2009), Förderung der Kompetenzen von Kindern und Jugendlichen. In J. Milberg (Eds.), Förderung des Nachwuchses In Technik und Naturwissenschaft, (pp. 15-60). Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-01123-8_1.

[9] OECD (2009), Education Today – The OECD Perspective. Paris, New York: OECD Publishing.

[10] Projektgruppe. (2011), Monitoring von Motivations-Konzepten für den Techniknachwuchs (MoMoTech). (Eds.) acatech – Deutsche Akademie der Technikwissenschaften.

[11] Randler, C. & Pfenning, U. (2010). Fallstudie Fachdidaktik Bionik im Modellversuch LeMoTech. Interner Ergebnisbericht. Universität Stuttgart/PH Heidelberg.

[12] acatech - German academy of science and engineering & VDI - The Association of German Engineers. (2009), Nachwuchsbarometer Technikwissenschaften. Careers in Science and Engineering: Trends, Expectations and Attitudes of Young People. Berlin: Körber Stiftung.

[13] Ziefle, M., Jakobs, E.-M. & Arning, K. (2009), Wege Zur Technikfaszination. Sozialisationsverläufe und Interventionszeitpunkte (Acatech DISKUTIERT). Berlin: Springer. https://doi.org/10.1007/978-3-642-04983-5

[14] acatech - German academy of science and engineering. (2011), Monitoring von Motivationskonzepten für den Techniknachwuchs (MoMoTech). Heidelberg: Springer.

[15] van Tuijl, C., & van der Molen, J. H. W. (2016), Study choice and career development in STEM fields: An overview and integration of the research. International Journal of Technology and Design Education, 26(2), 159–183. https://doi.org/10.1007/s10798-015-9308-1

[16] Krüger, H. (1992), Vorberufliche Sozialisation. *German Journal of Research in Human Resource Management,* 318-341.

[17] Ivemark, B., & Ambrose, A. (2021), Habitus Adaptation and First-Generation University Students' Adjustment to Higher Education: A Life Course Perspective. Sociology of Education. https://doi.org/10.1177/00380407211017060

[18] Papadakis, S., Vaiopoulou, J., Sifaki, E., Kalogiannakis, M., & Stamovlasis, D. (2021). Attitudes towards the Use of Educational Robotics: Exploring Pre-Service and In-Service Early Childhood Teacher Profiles, Educ. Sci. 2021, 11(5), 204; https://doi.org/10.3390/educsci11050204

[19] Pfenning, U., Renn, O., & Mack, U. (2002), Zur Zukunft technischer und naturwissenschaftlicher Berufe. Strategien gegen den Nachwuchsmangel. Universität Stuttgart/Akademie für Technikfolgenabschätzung in Baden-Württemberg.

[20] Raufuß, D., (1991), Technik und Bildung. Franzbecker. Bad Salzdetfurth.

[21] Georg, W. (2005), Studienfachwahl: soziale Reproduktion oder fachkulturelle Entscheidung. *ZA-Information /Zentralarchiv für Empirische Sozialforschung*, 57, 61-82. https://nbn-resolving.org/urn:nbn:de:0168-ssoar-198476

[22] Maier, H. (1994), Bildungsökonomie. Die Interdependenz von Bildungs- und Beschäftigungssystem. Schäffer-Poeschel Verlag. Stuttgart

[23] Snow, C. P., (1967). Die zwei Kulturen. Literarische und naturwissenschaftliche Intelligenz. Ernst Klett Verlag. Stuttgart.

[24] Anger, C., Koppel, O., Plünnecke, A., (2018), MINT-Frühjahrsreport 2018. MINT – Offenheit, Chancen, Innovationen Gutachten für MINT Zukunft schaffen und Gesamtmetall. https://www.iwkoeln.de/fileadmin/user_upload/Studien/Gutachten/PDF/2018/MINT-Fr%C3%BChjahrsreport_2018neu.pdf

[25] Baethge, M., Teichler, U. (1995), Bildungssystem und Beschäftigungssystem. In: Lenzen, Dieter (Eds.): Organisation, Recht und Ökonomie des Bildungswesens. Enzyklopädie Erziehungswissenschaft. Band 5. Klett Verlag für Wissen und Bildung. Stuttgart.

[26] Gries, T. (1995), Wachstum, Humankapital und die Dynamik der komparativen Vorteile. J.C.B. Mohr. Tübingen.

[27] Morsch, R., Neef, W., Schoembs, A., Wagemann, C.-H. (1974), Ingenieure. Studium und Berufssituation. Akademische Verlagsgesellschaft. Frankfurt am Main.

[28] Bönkost, K.-J., Oberliesen, R., (1997), Arbeit, Wirtschaft, Technik in Schulbüchern der Sekundarstufe I. Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie.

[29] Institut für Demoskopie Allensbach, (1982), Kritik an der Technik und die Zukunft einer Industrienation. Demoskopische Nachwuchsanalyse für Ingenieurberufe. In: (Eds.) Ministerium für Wissenschaft und Kunst Baden -Württemberg. Bildung in neuer Sicht, Nr. 47.

[30] Rissiek, J. (1998), Investition in Humankapital. Deutscher Universitäts-Verlag. Wiesbaden.