Center of Excellence for
Technology Education

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Technology Education Today

International Perspectives

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Center of Excellence for
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Vol. 1

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Preface

We are proud to present the first book of the new Center of Excellence for Technology Education.

The Center of Excellence for Technology Education-Network (CETE-Network) is an international research association, consisting of leading academic research institutions within the sector of Technology and Engineering Education. Since 2015 and for the next three years the network has been and will be funded by the Federal Ministry for Education and Research (BMBF) and by the German Academic Exchange Service (DAAD) in the context of the programme line on thematic networks. CETE is directed by Prof. Dr. Ingelore Mammes, holder of the chair for School Research at the University of Duisburg-Essen. Academic partners of the network are the University of Luxembourg, the Delft University of Technology, the University of Applied Sciences and Arts Northwestern Switzerland, the University of Missouri as well as the University of Cambridge.

During the last years STEM education (Science, Technology, Engineering and Mathematics) has been high on the agenda of governments worldwide. The idea of a STEM oriented curriculum is to teach students interdisciplinarily in all four disciplines. But with a critical look at what policymakers and researchers develop for a comprehensive STEM education, it is clearly evident that in most cases the knowledge of the subjects Technology and Engineering are not included. This is the case even if Technology has become a compulsory subject in many countries and can be found in curriculums in all continents under different names like Technology, Design and Technology or it is more aligned with the use of computers like Information and Communication Technology (ICT). The growing importance of technology in all areas of our life not only requires advanced qualification of young professionals through vocational training in order to foster innovation as well as technical and societal progress, but also a technical literacy "for everyone" so as to cope with these environments and to be a technologically mature society. Humans not only develop competencies but also self-cognitions towards technology and convictions of their own effectiveness by actively dealing with technology.

CETE is supposed to endow the nationally and internationally only little developed scientific community with more potential. Engineering and Technology Education needs to develop competencies, promote talents and interests and thereby create a positive identification with technology in order to grant people actionability and maturity in an engineered world and in order to render society technological progress. Fulfilling these demands in the long run is the primary aim of the CETE network.

Through joint research projects, Ph.D. exchanges, guest-lectures as well as international workshops and summer schools, the exploration of Technology Education processes should be boosted. Furthermore, the work of excellent young academics in the research fields of technical sciences shall be supported by the network. In addition, findings based on research should be introduced to school practice by publications and advanced teacher-training through international study cooperation and digital courses for teaching and learning.

The book "Technology Education Today – International Perspectives" is the first edition of the series from CETE. This book provides the current state of international Technology Education in selected countries. It is written by all funding members of the centre. To outline the development of the subject and for an extensive international perspective of Technology Education today, the centre invited further researchers in the field of technological sciences to write about the Technology Education in their countries, too. This made it possible to describe the confusing field of technical education in an international context in one book. The book offers an excellent overview and first in-depth insights into the different approaches, structures and challenges in the implementation of Technology Education in the countries: Australia, Canada, Germany, Luxembourg, the Netherlands, New Zealand, Switzerland, Ukraine, the United Kingdom and the United States of America.

In 2017 the second book of CETE with the main aim of supporting young academics in presenting their own research will be published. It will be a peer reviewed book.

We would like to give our thanks to all who have contributed to this first international CETE book about Technology Education today. Thanks to all CETE members, researchers, teachers and children worldwide who have supported the authors of the book.

We are hoping it will prove a valuable resource for all who read and work with this book. As a group of researchers working together in a network, we want to make a significant contribution to the on-going international research in Technology Education. Hoping in the future that STEM education will include a more comprehensive Technology Education than today.

Remembering that a technology oriented society needs technically literate humans for further innovations which satisfy the social needs of a 21st century society.

Ingelore Mammes, Stefan Fletcher, Martin Lang & Dieter Münk

Technology Education in Germany

1. The Necessity of Technology Education in Schools

The growing importance of technology in all areas of our lives not only requires the advanced qualification of young professionals through vocational training in order to foster innovation as well as technical and societal progress, but also a technical literacy "for everyone" so as to cope with these environments and to be a technologically mature society (cf. Mammes, 2014; Mammes & Tuncsoy, 2013; ITEA, 2007; Bandura, 1995).

1.1 The Necessity of Technological Literacy

Terminology of Technology
To explain Technology literacy, at first technology itself has to be defined: according to Banse (2013), technology is understood as something constructed, man-made or manufactured artefacts in contrast to phenomena of nature, which are something taken for granted. Although technology is a socio-technical system fulfilling human needs (cf. Ropohl, 2009), it also not only considers artificial products but also their formation mechanism as well as their range of use. And in contrast to the phenomena of nature, Technology stands for the forced, complex, purposeful cooperation of them (cf. Wolffgramm, 1994).

Terminology of technological literacy
Thus, technological literacy is the ability of an individual, either working independently or with others, to responsibly, appropriately and effectively use technology tools to access, manage, integrate, evaluate, create and communicate information (cf. ITEA, 2007; Dugger, 2003).

Technological literacy will be developed with a technological socialisation not only by educating cognitive abilities but also by developing positive self-cognitions (e.g. self-concept, self-efficacy, self-esteem, interest and instrinsic motivation) towards technology because convictions of humans' own effectiveness as a part of their identity are responsible for dealing with technology in general (cf. Baumert & Geiser, 1996; Bracken, 1996; Bandura, 1977; Bong & Skaalvik, 2003). Thus, a lack of technological socialisation may not only result in a technological illiteracy due to a lack of competencies but it may also have an impact on identity development because corresponding self-cognitions will not be developed. As an outcome, humans will not identify with technology (cf. acatech & VDI, 2009; Bandura, 1977; Carberry et al., 2010).

A lack of technological socialisation may lead to self-cognitions of having poor skills and inept qualities when dealing with technology. In the worst case they develop a disinterest or aversion towards technology. Moreover, a negative self-concept with low self-esteem and a negative assessment of one's own technical competencies and the fear of failure and performance-breakdown may start a downward spiral with the competence assessment of a "lack of abilities" having a negative impact on attitude towards technology (cf. Ziefle & Jacobs, 2009). As a result, interaction with technology will be avoided, thus excluding various career perspectives such as the choice of technically-oriented study courses and professions (cf. Martschinke, 2005; Hansford & Hattie, 1982).

Especially girls are affected by this. They are less often challenged to repair artefacts or given technological toys by their parents than boys (cf. Bast, 1991). So they come into contact with technology less often and thus often develop negative cognitions as, for example, disinterest (cf. Mammes, 2004).

The quality of technological socialisation as an important part of developing a technologically-oriented identity is influenced by artefacts and activities which are offered to humans. It also depends on technological experience (cf. Carberry et al., 2010; Bong & Skaalvik, 2003).

1.2 Technology Literacy and Technology Socialisation

A technological socialisation is essential to familiarise people with technology by dealing with it from early childhood throughout their youth up to possible vocational training or a technologically-oriented study course (cf. acatech & VDI, 2009; cf. Mammes, 2014; Ziefle & Jacobs, 2009; Angele, 1976).

Technology socialisation outside of the classroom has changed because of industrialisation and computerisation, which has resulted in a growing loss of comprehension of technical objects and processes as well as traditional play opportunities (acatech & VDI, 2009; cf. Ziefle & Jacobs, 2009). While technical objects have steadily become ever-present components of work and daily life, their functionality, however, remains unknown most of the time. Sealed plastic housing, modularised constructions as well as electrical components make an insight difficult. Thus, it has become almost impossible to understand their interaction (Tully, 2003; ITEA, 2007). Due to the complexity of mostly automated production processes, the manufacturing of products is no longer visible and therefore understandable. Based on this reduced perception, a version of reality may be developed, which presents an oversupply of affordable products without anyone being able to grasp their development conditions and technological assessment (Mammes, 1997). Toys have also become part of this development. An active interaction with technology, using their own construction of machinery and devices with the help of construction kits will seldom take place in today's children's rooms. Instead, modern communication media, such as computer games and applications, have emerged into shaping an interaction with technology rather characterised by simulation (cf. acatech & VDI, 2009; Renn & Pfenning, 2010; Ziefle & Jacobs, 2009).

In view of the above, parents call for a deliberate interaction with technology (cf. Bertram, 2012). This "technology education" (Ziefle & Jacobs, 2009, p. 74) contains all forms of deliberate and systematic influence on the child's personality with the aim of imparting knowledge and abilities for the development and use of technology as well as an interest in technology. In this context, Angele (1976) discovered significant correlations between attitudes towards technology, the knowledge about technology as well as the understanding of technology and parents with a technical hobby. According to this, children with such parents have more experience in interacting with technical objects than others.

But in such educational processes many parents reach their limits with regard to their own technical abilities and skills as well as their knowledge about technology. Therefore, the most common form of interaction with technology is the joint configuration and installing of technical equipment along with the joint use of technology. Thus both children and parents see the responsibility for technological education in schools as an institution not only to develop seminal competencies but also positive cognitions (e.g. interest, self-concepts) towards technology (Ziefle & Jacobs, 2009).

2. The Need for Technology Education in Primary Schools

International comparative tests on school quality determined that German pupils at the average age of 13 show average achievements and little interest in natural sciences and technology (cf. Bos et al., 2008; OECD, 2007; 2014). National studies support these results especially for the area of technology education (cf. acatech & VDI, 2009). In summary, adolescents still have negative self-cognition regarding technology.

On average, at the age of eight, children become increasingly conscious about their intellectual abilities. At this point "being different" not only manifests itself in physical concepts but in feelings and thoughts. At this age, children have already developed a concept about their individual abilities and skills. The development of the self-cognitions is not achieved on the children's own initiative, but is instead heavily influenced by interpersonal relationships. For example, children's abilities are compared to those of other children and people in their social surroundings endow them with abilities by assumption (cf. Müller, 2002; Hellmich, 2010).

A lack of technology socialization in early childhood can thus lead to the development of negative self-cognitions with regard to using technology. In order to maintain the developing cognitions, subsequent use of technology is avoided or is experienced as negative. These kinds of experiences often result in a low self-esteem and a negative assessment of one's own technical competence. Later on, the fear of failure and performance breakdown may start a downward spiral with the competence assessment of "lack of abilities" having a negative impact on the attitude towards technology (Ziefle & Jacobs, 2009, p. 18).

As a result, educational policy demands early learning initiatives. Already in preschool and primary school, boys and girls are supposed to be challenged and encouraged in order to build competencies that they will need for future learning processes. The children are supposed to acquire early knowledge and skills, to establish the grasp of concepts and self-assurance and – most of all – an interest in topics related to natural sciences and technology (cf. GDSU, 2013; Mammes, 2001; 2008b; Rohaan, 2009). Apart from early technology socialisation at home, the institutionalised or formal promotion of technology is very important since it can help to compensate for a lack of experience at home (cf. acatech & VDI, 2009). Studies show that a deliberate technology education at school will trigger interest in natural science and technology and foster knowledge and skills and, furthermore, reduce the gender difference in interest in technology (cf. Conrads, 1992; Mammes, 2001; cf. Hartinger, 1997; cf. acatech & VDI, 2009). Thus, an institutionalised promotion of technology not only supports the responsible participation in social life but also prevents technical illiteracy and plays a major role in the development of equal opportunities.

Early technology education can trigger interests already in primary school which, as the common entrance level into the educational system, can pursue the postulates of educational policies for early education in natural sciences and technology (cf. Mammes, 2001). Here educational plans and curricula set directions.

2.1 Institutionalisation of Technology Education on the Basis of Curricula

The different curricula for primary schools of the 16 federal states in Germany mostly subsume technical education under the area of "general science" or list it under fields such as Humankind/Nature/Culture (Baden-Wuerttemberg), Sculptural Composition (Lower Saxony) as well as Aesthetic Education (Mecklenburg-West Pomerania).

Since the end of the 1990s when Biester (n.d.) determined in a study that in almost all federal states technical topics are still noticeably underrepresented, and Blaseio (2004) verified these results, things have changed (cf. Biester, n.d.; Mammes, 2008b). Advice for strengthening the natural science and technology education from the conference of educational ministers in 2009 provided a homogenisation of the different curricula. Thus, the Society for Teaching of Elementary Science Education developed a policy document about the distribution of elementary science educational fields which contributes to the current situation of technology education in primary schools (cf. Möller, 2010). A study by Mammes & Schäffer (2014) about the primary school curricula and their technology education contents in the 16 federal states of Germany shows different results than Biester and confirms the influence of the policy document. With a snap reading method (cf. Blaseio, 2004), the current distribution of technology education aspects in the curricula are determined. The results represent technology education in almost every curriculum of each federal state, although the denomination of the subject areas as well as their structure and contents are different (Mammes & Schäffer, 2014). The increased represented subject areas are

- stability of technical artefacts (e.g. construction of buildings),
- tools, hardware and machines (e.g. functionality of drilling machines),
- workspaces & occupation (e.g. production processes)
- transformation and utilization of energy (e.g. use of water power), as well as
- technical inventions (e.g. follow-on consequences of letterpress printing).

2.2 Teacher's Professionalism as a Barrier for Implementing Technology Education?

As a consequence of the latest results of international comparative tests on school quality and the related discussion on the quality of teaching the public focus has once more been shifted to the teacher. Teachers' skills, beliefs and competencies are major influences on the quality of teaching. As experts for specific planning, the organisation, structure and reflection of teaching and learning processes, teachers display professional behavior and are required to possess problem solving skills needed in their profession (cf. Terhart, 2000; cf. Pfadenhauer, 2003). The relevant professionalisation takes place during teacher training when professional expertise as well as subject-related didactical and pedagogical knowledge is supposed to be conveyed.

However, professional behavior is always influenced by normative ideas and achievable possibilities (cf. Terhart, 2000): external conditions have an influence on professionalism and thus create an area of conflict between professional behavior and actual performance. The reality in schools (spatial conditions, material resources, local surroundings etc. (cf. Mammes, 2008a) often trigger conflicts between the teacher's own pedagogical standard and the feasibility of implementation. Furthermore, a lack of expertise also has an influence on the quality of pedagogical behavior in school and creates conflicts between the aspirations of educational policy, on the one hand, and reality on the other hand. Inadequate educational training can cause knowledge gaps, which prevent an implementation of institutional intentions.

The occupational group of primary teachers in Germany is particularly exposed to such areas of conflict. Here, the teachers' training in mainly two or three study areas is followed by the actual teaching of a variety of subjects and subject areas. As a result, the teacher's expertise becomes part of an area of conflict between the standards of educational policies (within the curricula), their feasibility and practicality in daily implementation.

Thus, and according to the TeBiS-study, it is not the institutionalisation through regulations and curricula which functions as an interface for the implementation of technical education. The teachers' expertise in teaching technology is crucial (cf. Möller et al., 1996; Helmke, 2009). Consequently, technical competency and technology education are connected. In general it is the teacher's decision which topics from the curriculum will be taught and to which subject priority is given. More than half of all teachers never choose topics of technology education for their lessons in primary schools and explain their resistance to teaching these topics with a lack of competency in this field. Teachers mention that during their training they have either never or only rarely been exposed to technical topics (cf. Möller et al., 1996; Bolte & Streller, 2007). In her research Rohaan (2009) also describes primary school teachers' lack of technical competency as the reason for a weak implementation of technical education in Dutch primary schools. But, an implementation through institutionalized consolidation does not seem to be enough.

The aforementioned studies point to a contradiction between the prescribed postulates of educational policy and professionalism connected with expertise. Disciplinary knowledge and qualification and the standards of politics and society seem to differ.

In order to solve the dilemma between the postulate of educational policy for the early promotion of technical education, on the one hand, and the area of conflict between the teachers, on the other hand, personnel development seems to be necessary.

2.3 Prospect

Technology education in primary schools is essential. Primary schools as the first educational institution for all children (regardless of their culture, religion or gender) have to have influence on the development of the pupils' self-cognitions including compentencies and have to support them to become realistic. With technology socialization in mind, it is imaginable that many primary school pupils do not have positive cognitions or are indifferent in matters of technology. Because of the early point of intervention, technology education can change these cognitions or at least influence them by dealing with technology in a positive way. Thus, primary school teachers have to be professionalized to teach technology by enabling them to transfer the contents of the curricula in daily practice. Then young children – as well as society – will be prepared for the future.

3. Technology in General Education at Lower Secondary Level

Currently there are in Germany diverse initiatives to promote technical education, for example engineering academies, robotic competitions or student laboratories. In contrast to the many initiatives, technology, as a separate school subject or as part of a subject area, gets less attention from the educational authorities. Technology education in general schools at lower secondary level is still, despite intensive efforts by didactics experts, technology teachers and the interest groups of the technology, a marginal subject. Technical content is only to a very limited extent represented in the curricula of lower secondary schools. Moreover, the structural and didactic approaches are dependent on the federal state and school forms (Hartmann, 2008), and there are few uniform standards. The reason for this is perhaps that the transfer of technical education as a stand-alone subject in Germany is comparatively new and has not yet had such a long tradition compared to other subjects such as mathematics, science or languages.

Regarding the research, the low level of political interest in the subject technology becomes apparent. In the big politically significant education studies such as PISA and TIMSS, technology content was previously taken into account, if at all, only as marginal sections of scientific content.

3.1 Content and Standards of Technology Education at Lower Secondary Level

With the decision to establish educational standards by the standing committee of the German ministers of culture (KMK) in 1997, an attempt was made to set national compulsory standards for the skills development of students. The aim of the educational standards is to establish centralized educational objectives and the skills that the pupils should have acquired by a certain grade. The educational standards form the basis for an evidence-based education policy. This should, on the one hand, contribute to better transparency in school work and, on the other hand, allow a nationwide evaluation of learning object results. So far, compulsory educational standards for the intermediate level of education after grade 10 have been introduced in all federal states, regardless of the type of school, for the subjects: German, mathematics, the first foreign language, physics, chemistry and biology. Despite intensive efforts by interest groups, it has not yet been possible to persuade the KMK to adopt universal educational standards for technology education. This may, on the one hand, be due to the heterogeneity of federal state specific solutions in the implementation of technology in general education; on the other hand, it may also be due to the specifics of the subject technology itself. Technical knowledge is constantly evolving due to the high dynamics of technological developments. In this sense, technology is fundamentally different from many other subjects in general education (Fletcher, 2011). But at least one recommendation (VDI, 2007) for educational standards for technical education, which was developed by the German Agency for technology education (DGTB) and the Association of German Engineers (VDI) with the participation of educational researchers and specialist teachers, has been widely accepted (see table below). Based on the structure of the KMK educational standards a division into areas of competence and requirement levels has been created.

The five areas of competence outline the knowledge, skills, abilities and attitudes that will enable students and pupils to act in their personal and social situations in a successful way with regard to technology. Here it becomes clear that a technical general education not only seeks to build an understanding of technical systems, but is aimed at a broader understanding of technology. These include skills such as technical design and manufacturing processes, the use and application of technology, the ability to develop and exchange technology-related information as well as the important area of the ability to assess impacts of technology on the environment, economics and society.

With regard to the specified levels of performance, different stages of development in the respective areas of competence are outlined. The requirements at level I demand the reproduction using simple technical facts and technical methods.

The requirements at level II contain reorganizing and transferring technical expertise and professional methods to solve simple technical problems. The level of requirements at stage III is characterized by a problem-oriented application and transfer of technical knowledge and methods to complex issues.

Table 1: VDI recommendation on educational standards for the subject technology for the Graduate degree after grade 10 (VDI, 2007).

Competence Areas	Level of standards		
	I Level	**II Level**	**III Level**
understand technology	describe features of known technological systems and processes	transmit features of technical systems and processes in similar systems and explain their effects	analyze features of complex technical systems and processes and discuss their effects
design and manufacture technology	find a simple solution for a given technical problem under Instructions and produce it properly and safely	find autonomously a solution for a given technical problem and produce it properly and safely	find solutions for an identified technical problem, justify the selection of one, then autonomously plan, properly and safely manufacture and optimize
use technology	under instruction, appropriately select, use and dispose of technical systems and processes	autonomously select, use, care, maintain and dispose of technical systems and processes	select technical systems and processes based on selection criteria and use, maintain, service, troubleshoot, repair and dispose of them.
evaluate technology	understand the evaluation of technology and the criteria used comprehend predetermine ratings of technology and its criteria	assess given evaluations of technology and make your own decisions predetermine ratings of technology and make decisions	make own evaluations of technology by selection of appropriate methods and criteria and give reasons for it
communicate technology	search for technical information, read and present simple technical documents	research and select technical information independently create and present technical documents using appropriate technical language and graphics, and also respond to the comments of others in a proper way.	find out autonomously complex technical information from various sources, structure these using appropriate technical language and graphics and present, discuss and react appropriately to the comments of others.

3.2 Implementation of Technology Education in the Different School Types of Lower Secondary Level

In Germany, a temporal structure of the general education system is carried out at the three school levels: primary, lower secondary and upper secondary education. The first level is the primary education. Here you will find a common learning from the first grade to fourth grade.[1] After learning together in primary schools, at lower secondary level a high degree of differentiation of school types takes place. At the end of the fourth grade, the children receive a recommendation of the school type for their secondary education. This stage includes grades 5–10 and ends with the so-called intermediate school leaving certificate. In accordance with the recommendations of primary school teachers and the wishes of the parents, it is possible to choose between the following five types of schools: lower secondary school, secondary school, comprehensive school, grammar school or special school.

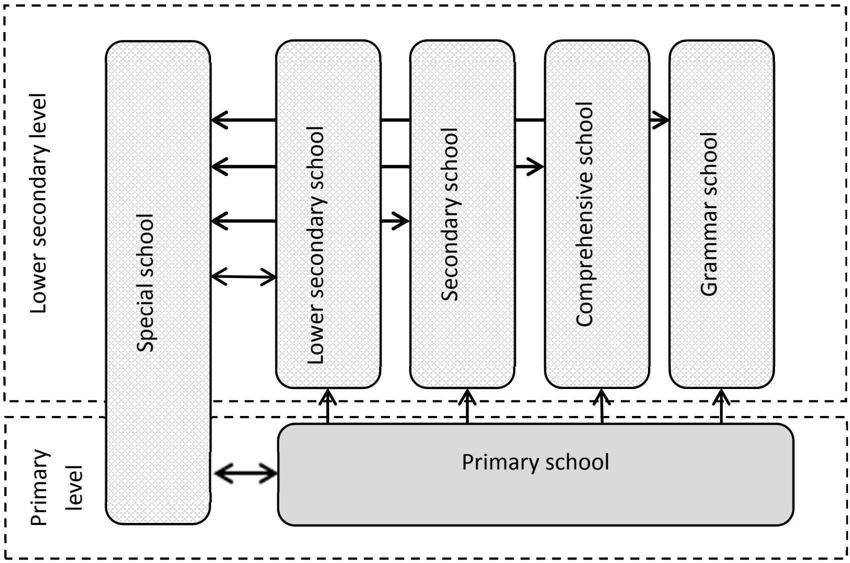

Figure 1: The structure of the general education system in Germany at the level of primary and lower secondary education level

1 One exception are the federal states of Berlin and Brandenburg. In these countries, primary education comprises six grades.

The following is a brief overview of the current implementation of technology education in the different school types at the lower secondary level in practice. For reasons of clarity, a consideration of the differences between the federal states is not included. It should be pointed out that considerable differences between the federal states exist both in terms of the provision of the school types as well as the content design of the curricula. Accordingly the comments on the individual type of schools should be regarded as generalized trends that are not always true for all federal states in detail.

3.3 Technology Education at Lower Secondary Schools

The curriculum at the secondary school is intended to provide a basic general education. The technological education is usually heavily based on practice and prepares students directly for working life. Technological content at the lower secondary schools is taught as part of the subject area business and employment studies.

This subject area provides a combination of the subjects technology, business and home economics. Moreover, technology is still taught in the context of the subject work-economy-technology or nature and technology, or in some states as a stand-alone subject. These subjects are compulsory in the lower secondary school, starting with the 5th or 7th grade. In most cases the number of school hours may be increased by additional compulsory elective offerings in the different fields of business and employment studies. The technological education at the lower secondary school should in particular build on the pupils' life and experience. Contents are scientific principles and applications of technology as well as economic, ecological and social effects of technology. In almost all federal states, computer literacy is also a part of the technological education. In terms of the didactic methodical implementation, an action-oriented focus of instruction is mostly aimed at giving space for practical experience to the students. Typical teaching methods are the practical task, projects, experiments or product analysis. In practice, however, the teaching is often reduced to the training of simple basic craft skills, such as sawing, drilling, filing etc. As a result, the students are often busy creating simple handmade practical everyday items. Another typical component of technological areas of learning is the subject of vocational orientation. Here students are informed about technical professions often in conjunction with an internship in manufacturing companies. Through this often one-sided focus, key areas of general technical education are neglected, such as the training about typical thinking and behavior within technology (design, drafting, goal orientation) as well as the development of skills in relation to the assessment of the impacts of technology.

3.4 Technology Education at Secondary Schools

Teaching at secondary schools is aimed at the provision of an expanded basic education. The secondary school prepares pupils for vocational education, a career in the public service or attending technical schools or upper secondary schools. Like the lower secondary schools, the teaching of technology is carried out in the subject area business and employment studies or as a stand-alone subject. In contrast to the orientation of the lower secondary schools, where the subject business and employment studies is a compulsory subject, it is offered in grade 7 to 10 at most secondary schools only as an optional subject.

A resulting problem is that the subject technology can be chosen as an alternative to the second foreign language. As a second foreign language is a prerequisite for moving to upper secondary level, an access to upper secondary school is not possible with the choice of the subject technology. As a result, the subject is especially selected by weaker students. This often affects the design of the technology lesson, which is then oriented strongly towards craft aspects and dispensed without scientific orientation like in the lower secondary schools.

3.5 Technology Education at Comprehensive Schools

In many federal states, the comprehensive school is an alternative school type to the traditional tripartite school system of grammar school, secondary school and lower secondary school. It is characteristic of this type of school that a differentiation between educational pathways takes place within a school form. At most comprehensive schools, technology educational content is well established. In North Rhine-Westphalia, for example, the subject area business and employment studies is a compulsory subject at grade five with a total number of 10–12 weekly hours in all grades. In addition, the subject technology can be chosen in grades 6–10 for a total of 10–15 hours per week in all grades. The aim of the subject business and employment studies is to be able to convey specialist knowledge and specialized practices that enable the learner to decide and act responsibly in work-related situations. Characteristic of the learning area work teaching is that the world of work is to be accessed from different disciplinary perspectives. Characteristic of the subject technology is the imparting of knowledge about technical processes and systems and empowering students to be able to develop technical systems in a goal-oriented way. Ideally, this can be achieved by close integration between theoretical concepts and knowledge and their practical implementation and application. In order to achieve this, schools must be equipped with technical experimentation and learning material. Particularly successful learning media which have been established are, for example, the robots from "Lego Mindstorms", with which the students are able to construct autonomous and interactive robotic systems. The content areas of technological education at the comprehensive schools differ strongly among the federal states. Typical content fields that are found in almost all curricula are: production technologies, the issue of energy supply as well as the information and communication technology.

3.6 Technology Education at Grammar Schools at Lower Secondary Level

At grammar schools, the subject technology is a very young subject without tradition and is not offered in all federal states at general schools. The traditional humanistic grammar school has taken a long time to recognize technology as a general content. In the tradition of the grammar school, technology is too closely linked to a focus on the world of work, to application-oriented education and does not correspond to the image of a science-oriented education. Meanwhile, however, a reorientation has taken place in almost all federal states. It has been recognized that technology is an important part of our society and can make a significant contribution to social change and development and should therefore not be absent from secondary school education. Also from a theoretical didactic point of view, technology has legitimacy in general education. Technology is from educational theory (see e.g. Roth, 1965), from scientific theory (see e.g Ropohl, 2004), as well as from an educational and practical view (see e.g. Buhr & Hartmann, 2008) significant for general education.