This report, directed by Abdellatif Benachenhou, IIEP, is part of the Institute's research on 'The implications for educational planning of scientific and technological development policies'

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The development of scientific and technological research in the German Democratic Republic and its implications for training

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with

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(Central Institute for Higher Education)

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The IIIEP research on educational planning and scientific and technological development policies

One of the principal underlying motives in the Institute's past activities has been the concern to fight effectively against inequalities of access and opportunity in the field of education. While this remains a priority, the Institute also needed to orient its research and training programme in the direction of one of the most glaring of contemporary inequalities, namely those prevailing between differing levels of scientific and technological development. Recent experience has shown that this inequality, which must be viewed within the economic and socio-political context from which it springs, often determines many others, including those besetting education.

One of the principal tasks of Unesco is to help in enhancing the scientific and technological potential of those of its Member States which suffer from these inequalities. This is founded on the conviction that economic growth and social change cannot be sustained without the corresponding development of local technological capabilities. Research on this theme by IIIEP is meant to contribute to this knowledge by building on the Institute's past work related to the relationship between education, work and employment.

This research programme does not in itself attempt an economic and social analysis of technological policies - although it does of necessity take them into account - but is chiefly concerned with investigating the relations between the various scientific and technological development policies on the one hand, and the content of educational policies and educational planning processes, methods and techniques on the other. The resulting conceptual, methodological and technical effort could ultimately be a source of enrichment to the Institute's training activities. The aim of these research studies and analyses is to examine the links between various policies and decisions relating to the processes of technical change and on-going educational policy and practice, in
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order to identify the role effectively ascribed to educational planning, and possibly to draw conclusions with a view to improving its relevance and effectiveness.

In giving consideration to the diversity of scientific and technological policies and the diversity of the economic structures into which they have to fit, the research aims at revealing - by using existing work and results where possible - the processes by which the different qualifications or skills necessary to the implementation of these different technological policies are produced. In particular, attention has been paid to the criteria that govern the choice of different programmes and streams, and to the linkages, notably between science and technology teaching, technical teaching and vocational training, as well as to the relationship between training and production, and between higher education, applied research and fundamental research.

The choice of the research area was predicated on the assumption that specific industries which have been undergoing significant technological development and promoting development in other industries should be given priority. This was the case with the computer industry, which has been experiencing revolutionary changes in recent years that have had a significant impact on the employment and qualification structure both within that industry and in other industries through the process of automation. These changes in employment, qualification structure of the work force, and the corresponding changes in educational and training requirements deserve analysis, understanding and articulation.

One of the countries that has an explicit, planned strategy for the development of its computer industry, and of education and training, is the German Democratic Republic. It was therefore felt that an analysis of the development of this industry in the GDR, and its implications in the field of training, would not only be useful for the country itself but also for other Member States of Unesco that are initiating technological changes in this industry and are looking for support from the education system to enhance such changes.

This study was undertaken jointly by IIEP and a team of researchers from the Central Institute for Higher Education of the GDR. The authors are grateful to Dr. Peter Arméliin, Ms. Christa Baejer, Dr. Barbara Haenschke, Dr. Wolfgang Kehr, Dr. Hans-Joachim Richter, and Dr. Karl-Heinz Zieris, who contributed to the different chapters of the study.
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Chapter 1
Outline of the initial social conditions and the tasks to be solved in the German Democratic Republic

1.1 Stage of development and initial conditions

The German Democratic Republic is a socialist State of workers and farmers, the social foundations of which are based on "the firm alliance of the working class with the class of co-operative farmers, the intelligentsia and the other sections of the people, the socialist property of means of production (and) the management and planning of social development in line with the latest discoveries in science".¹

At the end of 1985, 16,640,000 people² lived on a territory of 108.333 square kilometres, demographic development is marked, in principle, by simple reproduction. As a result of the First and Second World Wars and the post-war period, relatively marked structural changes are taking place in the composition of the diverse age-groups of the population. An approximate 8.54 million citizens (excluding


² These and all other statistical figures—if no other sources are indicated—are taken from the Statistical Yearbook of the German Democratic Republic of 1986 or have been calculated on the basis of the figures given therein. Figures in some of the tables may not total correctly due to rounding.
The development of scientific and technological research in the GDR and its implications in the field of training

Table I: Proportion of employed in the different economic sectors in 1949 and 1985 (in %)

<table>
<thead>
<tr>
<th></th>
<th>1949</th>
<th>1985</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Industry</td>
<td>27.9</td>
<td>37.9</td>
</tr>
<tr>
<td>Producing trades (excluding building trade)</td>
<td>8.6</td>
<td>3.1</td>
</tr>
<tr>
<td>Building industry</td>
<td>6.5</td>
<td>6.8</td>
</tr>
<tr>
<td>Agriculture and forestry</td>
<td>30.7</td>
<td>10.8</td>
</tr>
<tr>
<td>Transport and communications</td>
<td>6.1</td>
<td>5.8</td>
</tr>
<tr>
<td>Post and telecommunications</td>
<td></td>
<td>1.6</td>
</tr>
<tr>
<td>Commerce</td>
<td>8.5</td>
<td>10.2</td>
</tr>
<tr>
<td>Other production branches</td>
<td>12.4</td>
<td>2.9</td>
</tr>
<tr>
<td>Non-production branches</td>
<td></td>
<td>21.0</td>
</tr>
</tbody>
</table>

apprentices), including 4.20 million women, i.e. 51 per cent of the total population, were working at the time in question. This relatively high proportion in terms of world standards is explained by the guaranteed right to employment in the GDR and also by the high proportion of working women. More than 80 per cent of all women of working age

3 In the GDR, this age-group of the female population is made up as follows: persons aged between 15 and 60 years plus 5/12 of the persons aged between 14 and 15: for the male population the maximum working age limit is 65 years.
hold jobs, which reflects the equality of women in the GDR. Table 1
gives the proportions of persons employed, according to economic
sector, for the years 1949 and 1985.

This change in the structure of the working population clearly indi­
cates that the GDR is a highly industrialized country with an advanced
agriculture and infrastructure. This is also evident from the propor­tion
of the individual branches in the gross national product (GNP) and the
net product (NP) (see Table 2). With a per capita national income of
14,036 Marks per inhabitant, and of 33,798 Marks per production
worker, the GDR ranks among the world’s leading ten to fifteen highly
industrialized countries.

Table 2: Share of the production in the GNP and the NP in 1985
and in the NP in 1949 (in %)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry (including producing trades, but not building trade)</td>
<td>72.5</td>
<td>70.3</td>
<td>48.4</td>
</tr>
<tr>
<td>Building industry</td>
<td>6.9</td>
<td>5.9</td>
<td>5.4</td>
</tr>
<tr>
<td>Agriculture and forestry</td>
<td>8.7</td>
<td>8.1</td>
<td>29.3</td>
</tr>
</tbody>
</table>
| Transport and communic­
cations, post and telecommunications | 5.1       | 3.9       | 6.9       |
| Domestic trade         | 4.8        | 8.9       | 7.7       |
| Other production branches | 2.0       | 2.9       | 2.4       |

The major part of the national income (96.7 per cent) is provided
by the socialist economic areas, above all the nationally-owned
combines and enterprises and the socialist co-operatives of agriculture
and trade; a further 0.5 per cent comes from small private firms or
craftsmen's establishments; this proportion, however, varies in the indi­
vidual economic areas, for instance between 5.9 per cent in the building
industry, 3.7 per cent in agriculture and 2.3 per cent in industry and the
producing trades.
This social and economic structure is the foundation for a systematic development of the national economy in compliance with social standards, which is based on the connection between centralized State planning, on the one hand, and autonomous planning in the combines, enterprises and institutions, with a comprehensive inclusion of the workers, on the other hand. The potentialities offered by this course are above all evident in the continuous and dynamic economic and social advancement of the country.

Despite the economic crisis in the world market, which also had repercussions on the GDR, a constant economic growth could be ensured, and the material and cultural standards of the citizens could systematically be improved. The annually produced national income (for comparable prices) rose to nearly 200 per cent between 1970 and 1985, which is equivalent to an average annual growth of 4.6 per cent. In the same period, within the scope of the industrial ministries, labour productivity rose to 204 per cent (per worker and employee) or to 221 per cent (per working hour), and the time needed to produce industrial goods to the tune of 1,000 Marks decreased from 23 to 11.5 hours. Similar results in terms of the increase of labour productivity and efficiency were also achieved in other branches.

This was possible because the development of science and technology and the large-scale application of new knowledge by the society have increasingly become predominant in the country's economic strategy; also the construction of modern manufacturing plants has been combined with an increase in enterprise reconstruction and a comprehensive rationalization of production processes, including the application of the latest scientific discoveries. On this basis the real income of the population nearly doubled from 1970 to 1985, and a wide spectrum of social measures could be introduced in the same period—such as, the construction or modernization of 2.4 million dwellings, longer holidays for all workers, the partial introduction of the 40 hours working week\(^4\) for about 20 per cent of employees, e.g. mothers with two and more children, and stable consumer prices and charges for basic commodities and services, etc.

\(^4\) The legally fixed working time in the GDR is, in general, 43 3/4 hours per week.
This development is above all ensured by the high output of industry, which comprises all important branches of production, with mechanical engineering, vehicle construction, the chemical industry, electrical engineering/electronics and the light and food industry decisively marking the profile of industrial production (see Table 3).

Table 3: Share of the industrial branches in the industrial goods production (in %)

<table>
<thead>
<tr>
<th>Branch</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical industry</td>
<td>19.7</td>
</tr>
<tr>
<td>Mechanical engineering and vehicle construction</td>
<td>18.9</td>
</tr>
<tr>
<td>Food industry</td>
<td>13.5</td>
</tr>
<tr>
<td>Energy and fuel industry</td>
<td>12.2</td>
</tr>
<tr>
<td>Light industry (excluding textile industry)</td>
<td>9.5</td>
</tr>
<tr>
<td>Metallurgy</td>
<td>9.4</td>
</tr>
<tr>
<td>Electrical engineering, electronics, apparatus construction</td>
<td>8.5</td>
</tr>
<tr>
<td>Textile industry</td>
<td>5.8</td>
</tr>
<tr>
<td>Building materials industry</td>
<td>2.0</td>
</tr>
<tr>
<td>Water supply and distribution</td>
<td>0.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

The range of production in the individual areas and branches of industry is extremely comprehensive and varied. The development of industrial production in the GDR has a specific feature: namely, on the basis of the results and achievements obtained in science and technology, to give priority to such branches of production that are decisive for the attainment of a high technological standard and, at the same time, to create the preconditions for an ever more effective use of all raw substances, material and energy reserves, as well as for the manufacture of goods with a high value-added content.

The hierarchy of the individual industrial branches in terms of their growth rate at the different time-spans (see Table 4) reveals certain aspects of the GDR's economic strategy: constant promotion of those branches which are essential for scientific and technological advance, such as electrical engineering/electronics/apparatus construc-
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Table 4: Index of industrial gross production in the different industrial areas

<table>
<thead>
<tr>
<th>Area</th>
<th>1985 (1950 = 100)</th>
<th>1985 (1970 = 100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry total</td>
<td>1 131</td>
<td>211</td>
</tr>
<tr>
<td>Including</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Energy and fuel industry</td>
<td>427 (9)</td>
<td>173 (7)</td>
</tr>
<tr>
<td>- Chemical industry</td>
<td>1 389 (3)</td>
<td>227 (2)</td>
</tr>
<tr>
<td>- Metallurgy</td>
<td>1 188 (4)</td>
<td>202 (4)</td>
</tr>
<tr>
<td>- Building materials industry</td>
<td>928 (5)</td>
<td>163 (9)</td>
</tr>
<tr>
<td>- Mechanical engineering and vehicle construction</td>
<td>1 631 (2)</td>
<td>222 (3)</td>
</tr>
<tr>
<td>- Electrical engineering, electronics, apparatus construction</td>
<td>4 180 (1)</td>
<td>365 (1)</td>
</tr>
<tr>
<td>- Light industry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(excluding textile industry)</td>
<td>711 (7)</td>
<td>191 (5)</td>
</tr>
<tr>
<td>- Textile industry</td>
<td>605 (8)</td>
<td>176 (6)</td>
</tr>
<tr>
<td>- Food industry</td>
<td>732 (6)</td>
<td>167 (8)</td>
</tr>
</tbody>
</table>

tion, and mechanical engineering and vehicle construction; priority development of a local metallurgical basis in the fifties; an accelerated development of the chemical industry, and above all of petrol chemistry, the manufacture of plastics and elastomers, the production of
synthetic fibres and fertilizers in the sixties and seventies; rapid growth in the light, textile and food industry in the seventies, together with long-term orientations towards a closer synthesis of economic and social policies and a constant improvement of the material and cultural living conditions of the working population.

Table 5 gives the growth rates for some selected goods, produced from 1970-1985, and demonstrates that modern technical goods production, the upgrading of raw materials and substances and the manufacture of technical consumer goods are being given priority.

This dynamic development in industry, which is marked by a continuous growth, is also based on the development and utilization of the potentialities arising out of the planned co-operation with the USSR and the other socialist countries and gradual strengthening of economic integration within the Council for Mutual Economic Aid (CMEA). The economic structure and specific conditions of all countries in question (natural conditions, natural resources, parameters and limits of their potentialities, etc.) are taken into account in an attempt to ensure a complex development of the national economy and its different areas and branches, so as to interlink the phases and stages of reproduction in the interest of a highly efficient national economy. The socialist countries are working together in this sphere and have initiated a division of labour with regard to entire systems of products, series of appliances, products, sub-assemblies and components.

In the GDR, it was therefore possible over the past decades to expand the existing industrial branches and to construct new ones in line with the progress in scientific and technological knowledge (for example in metallurgy, petrol chemistry, heavy engineering industry, engineering of machinery for power production, shipbuilding, electronics, measuring and control engineering, etc.) and to create an efficient industry both in terms of the technological basis, the structure and the profile of production. This development was accompanied by steps and measures aimed at specialization and co-operation within the scope of the CMEA. The GDR has, for instance, over-capacities in rail vehicle construction and produces railway carriages and goods wagons, but no trams, which are primarily imported from Czechoslovakia. Similar examples could also be given for other industrial branches or product-groups. The standard reached in the division of labour and co-operation can also be demonstrated by the fact that, between 1970 and 1985, the proportion of specialized products in GDR exports to the
Table 5: Index of the industrial production of selected groups of products in the different industrial areas 1970-1985 (1970 = 100)

<table>
<thead>
<tr>
<th>Industrial area/group of products</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy and fuel industry</td>
<td>173</td>
</tr>
<tr>
<td>Electric energy</td>
<td>168</td>
</tr>
<tr>
<td>Town gas</td>
<td>182</td>
</tr>
<tr>
<td><strong>Chemical industry</strong></td>
<td></td>
</tr>
<tr>
<td>Petrol</td>
<td>192</td>
</tr>
<tr>
<td>Diesel fuel</td>
<td>175</td>
</tr>
<tr>
<td>Nitrogen fertilizer</td>
<td>273</td>
</tr>
<tr>
<td>Plastics/synthetic resins</td>
<td>283</td>
</tr>
<tr>
<td>Synthetic fibrous materials</td>
<td>333</td>
</tr>
<tr>
<td><strong>Metallurgy</strong></td>
<td></td>
</tr>
<tr>
<td>Crude steel</td>
<td>202</td>
</tr>
<tr>
<td>Rolled steel</td>
<td>155</td>
</tr>
<tr>
<td>Products of the second stage of manufacture</td>
<td>221</td>
</tr>
<tr>
<td>Electric steel</td>
<td>305</td>
</tr>
<tr>
<td><strong>Building materials industry</strong></td>
<td></td>
</tr>
<tr>
<td>Cement</td>
<td>145</td>
</tr>
<tr>
<td>Concrete products</td>
<td>153</td>
</tr>
<tr>
<td>Wall tiles, fittings</td>
<td>166</td>
</tr>
<tr>
<td><strong>Mechanical engineering and vehicle construction</strong></td>
<td></td>
</tr>
<tr>
<td>Cutting machine tools</td>
<td>222</td>
</tr>
<tr>
<td>Agricultural machines</td>
<td>334</td>
</tr>
<tr>
<td>Machines and installations for data processing</td>
<td>344</td>
</tr>
<tr>
<td>Machines and installations for the processing of plastics &amp; elastomers</td>
<td>527</td>
</tr>
<tr>
<td>Electric household appliances</td>
<td>361</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Industrial area/group of products</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Electrical engineering/ electronics/apparatus construction</strong></td>
<td></td>
</tr>
<tr>
<td>Electronic components</td>
<td>1453</td>
</tr>
<tr>
<td>Numerical control devices</td>
<td>1689</td>
</tr>
<tr>
<td>Physical and optical measuring instruments</td>
<td>279</td>
</tr>
<tr>
<td>Medical products</td>
<td>327</td>
</tr>
<tr>
<td>Television sets</td>
<td>176</td>
</tr>
<tr>
<td>(including colour TV)</td>
<td>54 fold</td>
</tr>
<tr>
<td><strong>Light industry</strong></td>
<td></td>
</tr>
<tr>
<td>Furniture/upholstered furniture</td>
<td>191</td>
</tr>
<tr>
<td>Wallpaper</td>
<td>244</td>
</tr>
<tr>
<td>Gymnastics and sports requisites</td>
<td>373</td>
</tr>
<tr>
<td>Artificial leather</td>
<td>271</td>
</tr>
<tr>
<td>Household and hotel china-ware</td>
<td>222</td>
</tr>
<tr>
<td><strong>Textile industry</strong></td>
<td></td>
</tr>
<tr>
<td>Curtains and drapery</td>
<td>176</td>
</tr>
<tr>
<td>Textile floor covering</td>
<td>169</td>
</tr>
<tr>
<td><strong>Food industry</strong></td>
<td></td>
</tr>
<tr>
<td>Meat</td>
<td>167</td>
</tr>
<tr>
<td>Yoghurt and yoghurt preparations</td>
<td>344</td>
</tr>
<tr>
<td>Instant drinks</td>
<td>530</td>
</tr>
<tr>
<td>Preserved fruits</td>
<td>222</td>
</tr>
<tr>
<td>Juices</td>
<td>253</td>
</tr>
<tr>
<td>Salt drinks</td>
<td>222</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
</tr>
</tbody>
</table>

in the GDR and its implications in the field of training.
The initial social conditions and the tasks to be solved in the GDR

CMEA countries rose from 1 to 39 per cent, including those to the USSR from 1 to 49 per cent.

All in all, it is evident that the GDR industry, because of its high level of development, occupies an important place in the system of the international socialist division of labour (in particular in such important branches as chemistry, mechanical engineering, electrical engineering and electronics, the glass and ceramics industry), which is instrumental for a rapid advance in key areas of scientific and technical progress, by pooling and concentrating the available potentialities, whilst at the same time improving specialization and co-operation, and in the creation of the basis for a continuous, dynamic economic growth also in the future.

Last, but not least, the productivity of industry depends on a modern organization of the entire reproduction process: 129 centrally administered combines under the respective industrial ministries, 95 locally administered combines under the regional economic councils of the 14 regions, as well as the bodies of economic control of the capital, constitute the backbone of industry. The combines are the basic form of organization of large-scale socialist production which, at the same time, have their own capacities for science and research. They can therefore constantly improve and render more effective the interrelations between science and production in the interests of accelerated innovation processes and a continuous increase in productivity and efficiency. This process is assisted by a many-sided expansion in co-operation between the combines, on the one hand, and the universities and similar institutions, institutes of the Academy of Sciences and other scientific academies, on the other hand, on the basis of agreements and contracts. This co-operation ranges from the joint strategic work aimed at the development of science and production, the co-ordinated approach to research projects, the pooling of efforts in the initial and further training of specialists, to the extension of the material and technical basis for scientific work. This, in essence, also applies in regard to the building industry, to transport and communications.

In 1985, socialist agricultural enterprises—i.e. 465 nationally-owned farms and 3,905 co-operatives—cultivated nearly 5.9 million hectares of arable land, which is equivalent to approximately 95 per cent of the entire area of agricultural land of the country. GDR agriculture disposes of a sound material and technical base, with a total of 158,000 tractors, 16,870 combine harvesters and many other modern machines, implements and installations. Based on the latest findings in science,
technology, agronomy and economics, agriculture increasingly becomes a branch of applied science. *Table 6* illustrates this fact.

---

**Table 6:** Index of selected features in agricultural production 1970-1985 (1970 = 100)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of agricultural land</td>
<td>100.0</td>
</tr>
<tr>
<td>- of which: Arable land</td>
<td>99.0</td>
</tr>
<tr>
<td>Employed in agriculture and forestry</td>
<td>92.5</td>
</tr>
<tr>
<td>Total yield of crop production per hectare of arable land</td>
<td>136.8</td>
</tr>
<tr>
<td>Number of cattle</td>
<td>112.3</td>
</tr>
<tr>
<td>Number of pigs</td>
<td>133.7</td>
</tr>
<tr>
<td>Animals for slaughter (live weight)</td>
<td>150.7</td>
</tr>
<tr>
<td>Cow milk (with 3.5 per cent fat content)</td>
<td>131.9</td>
</tr>
</tbody>
</table>

The supply of food products to the home market, with a high rate of per capita consumption, can entirely be ensured by inland sources—apart from some imported products which cannot be grown in the country because of climatic conditions. The processing industry may therefore rely on agriculture for the supply of raw materials.

The stable supply and the effective use of raw materials is of special importance to the GDR, given its specific raw materials basis. Despite huge reserves of lignite (more than one-third of the world production), mineral and potassium salt, and various kinds of sand and clay, the GDR has only very limited deposits or iron ore, copper, lead, tin, zinc, tungsten, molybdenum, uranium, oil and natural gas, and no hard coal mines. Consequently, the raw materials requirements can only be fully covered by local resources for some items, and for many other items only partially or even not at all. This gives an additional impetus to the existing marked orientation towards foreign trade and growing international commercial co-operation, above all with the socialist countries. *Table 7* shows the structure of exports and imports for 1985. The foreign trade turnover amounted to nearly 180.2 thou-
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Table 7: Structure of exports and imports in 1985 (in goods items)

<table>
<thead>
<tr>
<th>Exports</th>
<th>Imports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machines, equipment, transport vehicles</td>
<td>46.6</td>
</tr>
<tr>
<td>Fuel, mineral raw materials, metals</td>
<td>20.0</td>
</tr>
<tr>
<td>Other raw materials, semi-finished products</td>
<td>7.7</td>
</tr>
<tr>
<td>Industrial consumer goods</td>
<td>14.1</td>
</tr>
<tr>
<td>Chemical products, fertilizers, synthetic rubber, building materials, etc.</td>
<td>11.6</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
</tr>
</tbody>
</table>

sand million currency Marks in 1985, of which almost 66 per cent in transactions with the socialist countries, including the USSR as the most important trade partner with 38.5 per cent.

Apart from the important role of foreign trade in supplying the national economy with raw materials, the rapid increase in foreign trade turnover is above all determined by the division of labour, the specialization and co-operation resulting from economic integration within the scope of the CMEA. From 1970 to 1975 the foreign trade turnover rose to 188 per cent, from 1975 to 1980 to 161 per cent and from 1980 to 1985 to 155 per cent. This marked and growing international commercial integration of the GDR makes great demands on all processes and services linked with foreign trade activities. Parameters such as quality, efficiency, competitive prices of the products destined for export, or the most effective use of imported products are increasingly gaining ground. This underlines again the need for an ever more effective application of science and technology as a decisive factor for higher productivity and efficiency of science.

This economic expansion, above all in industry but also in agriculture, was accompanied by notable changes in employment, in the general qualification of workers and in the qualification structure. As can be seen from Table 8, the number of employed (excluding apprentices) rose, for instance, from 7.923 million in 1950 to 8.539 million in
The development of scientific and technological research in the GDR and its implications in the field of training

1985. In the same timespan the number of citizens of working age showed a downward trend with a decrease from 11.8 million in 1950 to 10.8 million in 1985 (see Figure 1).

At the same time, the number of those employed in industry rose to over 154 per cent (1950 = 100), with significant changes taking place in the employment structure of the individual industrial areas and branches. Table 9 shows the structure of employment in the different industrial areas in 1950 and 1985, together with the index of development of the employed in 1985.

This increase in the number of employed in industry is, in the main, attributable to two factors: a higher degree of employment of the population of working age, above all of women who are ensured equal rights in working life; and a decrease of workers in other economic areas, in particular in agriculture.

In the same period profound changes took place in the qualification structure of the employed (graduates of universities, technical college graduates, skilled workers) as well as in the trades and professions, which were accompanied by a marked rise in educational and cultural standards in general (see Table 10). These changes are the result of a long-term concept of socialist education based on the obligatory general 10-year polytechnical secondary school, followed up by a constitutionally guaranteed system of further education of youth at vocational training schools, technical colleges or universities and similar institutions, as well as adult education schemes run by the enterprises and a wide network of intellectual and cultural activities. This development in the qualification structure was accompanied by significant changes in the occupational structure. This is evident from the changed structure of training which alters the educational structure in the long run.

These changes in the structure of higher education and the different disciplines (see Table 11) not only brought about a significant expansion in terms of quality, but above all a rapid growth in the number of employed engineers, economists and teachers. As regards the latter, the increase is in particular the result of a long-term concept for the construction of a general 10-class polytechnical secondary school.

5 Completed vocational training means completion of the 10th grade plus 2 to 2 1/2 years of vocational training, or completion of the 8th grade plus vocational training generally for 3 years.
Table 8: Development trends of the population of working age (Rpwa), the employed and the share of employed in selected economic branches

<table>
<thead>
<tr>
<th>Year</th>
<th>Total population (in millions)</th>
<th>Total Rpwa</th>
<th>Employed (excluding apprentices)</th>
<th>Proportion of the employed (in %)</th>
<th>Industry</th>
<th>Agriculture</th>
<th>Non-production branches</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>18.388</td>
<td>11.782</td>
<td>7.923</td>
<td>29.2</td>
<td>27.9</td>
<td>about 11.5</td>
<td></td>
</tr>
<tr>
<td>1960</td>
<td>17.188</td>
<td>10.542</td>
<td>7.685</td>
<td>36.0</td>
<td>17.0</td>
<td>about 15.5</td>
<td></td>
</tr>
<tr>
<td>1970</td>
<td>17.008</td>
<td>9.881</td>
<td>7.769</td>
<td>38.8</td>
<td>12.8</td>
<td>17.5</td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>16.740</td>
<td>10.581</td>
<td>8.225</td>
<td>38.0</td>
<td>10.7</td>
<td>20.1</td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td>16.640</td>
<td>10.786</td>
<td>8.539</td>
<td>37.9</td>
<td>10.8</td>
<td>21.0</td>
<td></td>
</tr>
</tbody>
</table>

Source: This Table was compiled and calculated on the basis of figures given in the Statistical Yearbook of the GDR, 1955, p. 26 ff; 1981, pp. 91-93 and p. 344; and 1986, p. 111 and pp. 348-349.
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Actual figures

Estimated forecast

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>18.4</td>
<td>17.1</td>
<td>16.6</td>
<td>16.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active Population (a)</td>
<td>11.8</td>
<td>9.9</td>
<td>10.8</td>
<td>10.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employed</td>
<td>7.2</td>
<td>7.8</td>
<td>8.5</td>
<td>8.5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Degree of employment (b)

64% 73% 78% 78%


Figure 1: Population, active population, employees in the GDR, 1950-2000 (in million persons)
The initial social conditions and the tasks to be solved in the GDR

Table 9: Structure of employed persons in the different industrial sectors in 1950 and 1985 and index of development of the employed in 1985

<table>
<thead>
<tr>
<th>Industrial sector</th>
<th>Proportion of employed in % (1950 = 100)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1950</td>
</tr>
<tr>
<td>Energy/fuel industry</td>
<td>9.7</td>
</tr>
<tr>
<td>Chemical industry</td>
<td>8.7</td>
</tr>
<tr>
<td>Metallurgy</td>
<td>3.0</td>
</tr>
<tr>
<td>Building materials industry</td>
<td>6.1</td>
</tr>
<tr>
<td>Mechanical engineering and</td>
<td>23.7</td>
</tr>
<tr>
<td>vehicle construction</td>
<td></td>
</tr>
<tr>
<td>Electrical engineering/electronics</td>
<td>9.6</td>
</tr>
<tr>
<td>Light industry (excluding textile industry)</td>
<td>17.3</td>
</tr>
<tr>
<td>Textile industry</td>
<td>14.4</td>
</tr>
<tr>
<td>Food industry</td>
<td>7.5</td>
</tr>
</tbody>
</table>

Source: This table was compiled on the basis of the Statistical Yearbook of the GDR 1955, p. 126 ff; and 1986, p. 239.

and for the development of vocational training schools. Similar changes in the training and occupational structure, oriented towards the requirements of the society and the national economy in particular, could also be demonstrated for the spheres of technical and vocational training.

As a result of this development, 85 per cent of all those employed in the socialist economy had completed vocational or professional training at the end of 1985. This also applies in regard to agriculture, where the traditional backwardness in educational standards and qualifications could be overcome within three decades after the large-scale transition to co-operative production at the beginning of the sixties and the emergence of productive agricultural enterprises (see Table 12).
The development of scientific and technological research in the GDR and its implications in the field of training

Table 10: Development of qualification structures of those employed in the socialist economic sector (in thousands)

<table>
<thead>
<tr>
<th>Year</th>
<th>University-level graduates</th>
<th>Technical College graduates</th>
<th>Foremen and skilled workers</th>
<th>Semi-skilled and unskilled workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961</td>
<td>21.8</td>
<td>39.0</td>
<td>about 400.0</td>
<td>about 540.0</td>
</tr>
<tr>
<td>1970</td>
<td>39.2</td>
<td>68.2</td>
<td>480.0</td>
<td>412.0</td>
</tr>
<tr>
<td>1980</td>
<td>66.7</td>
<td>121.4</td>
<td>613.6</td>
<td>198.3</td>
</tr>
<tr>
<td>1985</td>
<td>75.3</td>
<td>133.9</td>
<td>641.3</td>
<td>149.5</td>
</tr>
</tbody>
</table>

Source: This table was compiled on the basis of the Statistical Yearbook of the GDR 1981, p. 105: and 1986, pp. 124-5. There are only partial data available for 1961.

The system of vocational and professional training and qualification in principle ensures the training of specialists for the different economic branches and areas of application, including science and research; only for such areas in which, as a result of the economic structure and natural conditions, there is a very limited need, does the GDR also use the opportunities of training—above all for university graduates—offered by the fraternal socialist countries. Yet there is a wide network of facilities for further training, supplementary and partial studies, etc. abroad, which continue to be developed and extended, above all for specialists working in key areas of scientific and technological development.

In 1985, a total of 2,042,900 pupils attended a general school, of whom 1,943,100 went to a general 10-year polytechnical secondary school; 377,600 apprentices learnt a trade at the vocational training centres; 162,000 students, including 99,500 full-time students, received training at the technical colleges, and a total of 129,900 persons, including 108,900 full-time students, studied at the universities or university-level institutions of the country.
Table 11: Development and proportion of university-level students in the different disciplines (1960 = 100)(a)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics natural sciences</td>
<td>14.2</td>
<td>9.1</td>
<td>9.5</td>
<td>6.4</td>
<td>6.6</td>
</tr>
<tr>
<td>Technical sciences</td>
<td>19.8</td>
<td>23.7</td>
<td>32.1</td>
<td>29.6</td>
<td>30.7</td>
</tr>
<tr>
<td>Medicine</td>
<td>12.9</td>
<td>12.1</td>
<td>6.7</td>
<td>10.3</td>
<td>10.4</td>
</tr>
<tr>
<td>Agricultural sciences</td>
<td>8.0</td>
<td>6.9</td>
<td>4.9</td>
<td>6.0</td>
<td>5.8</td>
</tr>
<tr>
<td>Economics</td>
<td>12.5</td>
<td>15.6</td>
<td>14.4</td>
<td>14.2</td>
<td>13.6</td>
</tr>
<tr>
<td>Philosphic historical sciences/political sciences and law</td>
<td>7.2</td>
<td>5.6</td>
<td>5.0</td>
<td>6.8</td>
<td>5.9</td>
</tr>
<tr>
<td>Cultural studies, aesthetics and sports and gymnastics</td>
<td>1.9</td>
<td>1.1</td>
<td>1.5</td>
<td>2.3</td>
<td>1.9</td>
</tr>
<tr>
<td>Literature and linguistics</td>
<td>3.9</td>
<td>1.4</td>
<td>0.9</td>
<td>1.7</td>
<td>1.3</td>
</tr>
<tr>
<td>Art</td>
<td>3.0</td>
<td>1.8</td>
<td>1.5</td>
<td>2.3</td>
<td>2.4</td>
</tr>
<tr>
<td>Pedagogical sciences/teacher training</td>
<td>15.0</td>
<td>22.0</td>
<td>23.2</td>
<td>20.1</td>
<td>21.0</td>
</tr>
<tr>
<td>Others</td>
<td>1.6</td>
<td>0.7</td>
<td>0.3</td>
<td>0.3</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Total number of students (1960 = 100) 55.3 100 143.4 130.0 130.0

(a) For all forms of study at university level (full-time studies, correspondence courses), figures are only available as from 1960. The figures for 1953 are only approximate calculations. This table was compiled on the basis of the Statistical Yearbook of the GDR, 1955, 1957 and 1986.

A well-established network of educational institutions spread all over the country ensures for all citizens their constitutionally guaranteed right to education and to initial and further training. Table 13 gives the numbers of educational establishments and teachers for the different levels of education.

This network of educational establishments is supplemented by a system of evening classes set up all over the country, as well as by adult
The development of scientific and technological research in the GDR and its implications in the field of training

Table 12: Training standards among those permanently employed in socialist agriculture, 1985 (in %)

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skilled workers</td>
<td>75.1</td>
</tr>
<tr>
<td>Foremen</td>
<td>6.5</td>
</tr>
<tr>
<td>Technical college graduates</td>
<td>6.7</td>
</tr>
<tr>
<td>University-level graduates</td>
<td>2.8</td>
</tr>
<tr>
<td>Those without completed vocational or professional training</td>
<td>8.8</td>
</tr>
<tr>
<td>All employed</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Education schemes attached to the combines, enterprises and institutions. In co-operation with the general and vocational training schools, the technical colleges and universities and similar institutions, these educational centres fulfil significant tasks in adult education and in the general and in-service training of the workers (see Table 14).

In 1984-1985 more than 285,700 citizens attended evening classes offering a wide range of courses in the fields of mathematics, natural sciences, social sciences, languages, culture and art, etc. In addition, library facilities are rich and varied, with 14,645 general public libraries and 3,938 trade union libraries; 6,471 books and brochures with a total edition of 144.6 million and 535 journals with 5,393 issues a year, including numerous scientific and popular science publications, were published in 1985. There are also some 63 museums in the GDR, 183 theatres, 819 cinemas, 88 orchestras, and numerous possibilities for gymnastics and sports, etc. The radio and television programmes, which can be received all over the country, have also their share in the dissemination of scientific results and knowledge and in the enrichment of intellectual and cultural life. Last but not least, this also applies in regard to the activities of the over 1,400 cultural centres and clubs, including their specialized circles of interest, and to the work accomplished by numerous social organizations with a particular commitment to education and culture, such as the Society for the Dissemination of Scientific Knowledge—URANIA—and its specialized sections, or the League of Culture of the GDR and its specialized groups.
Table 13: Number of educational establishments and teachers in the different spheres of education in the GDR (autumn 1985)

<table>
<thead>
<tr>
<th>Level of education</th>
<th>Number of establishments</th>
<th>Number of teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>General schools</td>
<td>5 864</td>
<td>173 689</td>
</tr>
<tr>
<td>Vocational training schools (for the theoretical instruction of apprentices) (a)</td>
<td>963</td>
<td>16 874</td>
</tr>
<tr>
<td>Technical colleges</td>
<td>239</td>
<td>11 940 (b)</td>
</tr>
<tr>
<td>Universities and similar institutions</td>
<td>54</td>
<td>30 060 (c)</td>
</tr>
</tbody>
</table>

(a) The practical training of apprentices is carried out at the respective enterprises directly or, in some cases at special training workshops.

(b) Excluding part-time teachers.

(c) Professors, senior lecturers, other teaching staff—excluding physicians/dentists in the medical areas.

These many-sided and ever increasing possibilities destined to provide for the varied educational requirements and the intellectual and cultural interests of the population at the same time leave scope for the development of their creative talents, which—as Marx stated—"in their capacity as the largest productive force will, for their part, have a retroactive effect on the productive force of labour".6

On this basis, the GDR is following a course of economic and social policy—called the main thrust—aimed at the improvement of material and cultural standards in line with the high speed of advancement in socialist production, growing efficiency, scientific and techno-

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Table 14: Development of further training of workers and employees in the socialist economic sector (excluding enterprises in agriculture, forestry and trade)

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
<th>Industry</th>
<th>Commerce</th>
</tr>
</thead>
<tbody>
<tr>
<td>1971</td>
<td>1,089,400</td>
<td>532,840</td>
<td>-</td>
</tr>
<tr>
<td>1975</td>
<td>1,446,750</td>
<td>655,470</td>
<td>215,110</td>
</tr>
<tr>
<td>1980</td>
<td>1,680,550</td>
<td>728,630</td>
<td>295,890</td>
</tr>
<tr>
<td>1985</td>
<td>1,796,550</td>
<td>784,470</td>
<td>286,480</td>
</tr>
</tbody>
</table>

logical progress and the increase of labour productivity. Guaranteed social security for all is a decisive factor in the country's economic policy. This comprises all aspects of life, ranging from guaranteed employment in accordance with acquired qualifications; good working conditions with efforts to reduce to a minimum monotonous and strenuous physical work; measures to improve the supply of food, industrial consumer goods and services; the provision of adequate housing—a comprehensive construction programme is envisaged to solve the problem of housing by 1990 (e.g. all families will have a dwelling of their own), better educational opportunities, health and social care from birth to old age and the extension of facilities for culture and sports.

1.2 Tasks to be solved

Future development will also be marked by the continuation of this course of action directed towards the welfare of the population. The main trend of this policy, to raise living standards alongside with economic advancement, has always been directed at ...
The initial social conditions and the tasks to be solved in the GDR

"... social progress in the broadest sense of the word. It is concerned with economic results, provision for the material and cultural requirements of the workers, high educational standards and a varied intellectual life for all, in which the socialist ideology is increasingly influencing the ways of thought and behaviour... That is why it is more than a temporary political variant... The application of this policy in practice will continue to be decisive for our work. The Socialist Unity Party of Germany will cross the threshold of the year 2000 along this road."7

In this context, the following trends were underlined at the XIth Congress of the SUP:

"We are focusing our attention on those sectors of the economy which are leading in this field. Above all it is important to establish closer links between science and production and vice versa. This applies in particular to the mastery of key technologies. There is no reason for us to fall behind in this respect. It is rather a matter of getting rid of outdated technological methods and of making greater headway than hitherto in the wide-scale development of high-quality products with the aid of the latest scientific findings."8

This clearly indicates that the economic strategy of the GDR is aimed at guaranteeing a constant economic growth and a steady increase in the productivity and efficiency of the national economy. This is


The development of scientific and technological research in the GDR and its implications in the field of training demonstrated by Table 15 which gives selected targets for the national economy for the period 1986-1990.

Table 15: Selected targets of the GDR economy for the period 1986-1990 (1986 = 100) (a)

<table>
<thead>
<tr>
<th>Target (in %)</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Produced national income</td>
<td>125.0</td>
</tr>
<tr>
<td>Industry:</td>
<td></td>
</tr>
<tr>
<td>- Goods production</td>
<td>123.0</td>
</tr>
<tr>
<td>- Net production</td>
<td>150.0</td>
</tr>
<tr>
<td>- Decrease of prime costs (annual average)</td>
<td>2.2</td>
</tr>
<tr>
<td>- Decrease of specific consumption on the annual average</td>
<td></td>
</tr>
<tr>
<td>--for important raw materials/substances</td>
<td>4.0</td>
</tr>
<tr>
<td>--for important sources of energy</td>
<td>3.3</td>
</tr>
<tr>
<td>- Labour productivity (on the basis of the net production)</td>
<td>150.0</td>
</tr>
<tr>
<td>Building industry:</td>
<td></td>
</tr>
<tr>
<td>- Output of the building industry</td>
<td>116.2</td>
</tr>
<tr>
<td>- Decrease of prime costs (annual average)</td>
<td>2.1</td>
</tr>
<tr>
<td>Agriculture:</td>
<td></td>
</tr>
<tr>
<td>- Cereals production 1990</td>
<td>11.9 million tons</td>
</tr>
<tr>
<td>- Animals for slaughter</td>
<td>2 635.0 kilotons</td>
</tr>
<tr>
<td>Export to the socialist economic area (1985 = 100)</td>
<td>129.0</td>
</tr>
</tbody>
</table>

A guaranteed steady economic growth and a highly productive national economy are essential for the achievement of these aims. That is why the economic strategy of the GDR is directed towards making the best use of all potentials and advantages offered by the socialist planned economy in order to accelerate scientific and technological progress decisively.

"The economic strategy of our Party, which covers the period up to the year 2000, is designed to combine the advantages of socialism still more effectively with the achievements of the scientific and technological revolution... The potential of all economies is being increasingly determined by microelectronics, advanced computer technology and computer-aided design and manufacturing and closely linked with these is the spread of other key technologies such as flexible automatic manufacturing systems, new machining techniques and materials, biotechnology, nuclear energy and laser technology. These represent tremendous challenges and at the same time splendid opportunities for swift product innovation, quality enhancement and cost reductions on a scale previously thought impossible. This is the field in which the rate of growth in labour productivity will be decided, and this in turn will determine the extent to which our economy will be able to satisfy the needs of the population, cope with the multitude of requirements arising from our country's internal development and hold its own in the international arena. At the same time, it will give rise to new conditions permitting the role of the working people within the production process to be changed, allowing them to be assigned more interesting and challenging tasks and improving working conditions to levels more appropriate to socialist production relations." \(^9\)

\(^9\) Ibid., p. 49.
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In saving 550 million working hours a year on the average—which is equivalent to the saving of 275,000 workers—it is, at the same time, intended to win workers for other production or non-production branches.

That is why the Five-Year-Plan (1986-1990) provides an accelerated extension of different areas of microelectronics including the development and production of special technological installations for this industrial branch. On this basis a rapid introduction of automated information processing is envisaged, above all in the spheres of computer-aided design and manufacturing, in production preparation and production itself, as well as a widespread application of modern computer technology to streamline work in all economic areas including management and planning.

Along with a manufacturing programme for industrial robots and automation technology, at least 60 or 65 new complex automation projects are scheduled to be introduced up to 1990 into the metal-processing industry and other economic areas, respectively, with a planned rise in output between 500 and 600 per cent. In the present Five-Year-Plan period, the output in biochemical production is envisaged to increase threefold, above all of substances for diagnostic purposes, drugs, enzymes and flavouring agents. In the chemical and metallurgical industry priority is given to the tapping of all available raw materials and their upgrading; the solutions to be achieved in this respect will have a decisive share in meeting the high and rapidly increasing demands of the processing industry as regards the quality of the materials and substances. The figures given in Table 16 are, inter alia, indicative of the ambitious targets set for the development of electrical engineering/electronics and mechanical engineering.

For the solution of these tasks an extended co-operation with the other socialist countries, above all within the scope of the Complex Programme of Scientific and Technical Progress of the Member Countries of the CMEA up to the Year 2000,\(^{10}\) agreed upon in 1985, is of outstanding importance. The GDR takes an active part in the materialization of all the five main trends fixed by this programme: electronization of the national economy; complex automation; promo-

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Table 16: Rates of increase in the manufacture of products of electrical engineering/electronics and mechanical engineering of special importance to the national economy, 1986-1990 (1986 = 100) (a)

<table>
<thead>
<tr>
<th>Branch/Group of products</th>
<th>Rates of increase 1986-1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical engineering/electronics</td>
<td>151.0</td>
</tr>
<tr>
<td>Including:</td>
<td></td>
</tr>
<tr>
<td>- Measuring and control engineering</td>
<td>182.0</td>
</tr>
<tr>
<td>- Electrical installations</td>
<td>147.6</td>
</tr>
<tr>
<td>- Electrical machines</td>
<td>159.0</td>
</tr>
<tr>
<td>- Numerical control devices</td>
<td>175.6</td>
</tr>
<tr>
<td>Mechanical engineering</td>
<td>132.0</td>
</tr>
<tr>
<td>- Cold working machine tools</td>
<td>152.0</td>
</tr>
<tr>
<td>- Cutting machine tools</td>
<td>147.0</td>
</tr>
</tbody>
</table>

(a) Gesetz über den Fünfjahrplan, op. cit., p. 12.

The initial social conditions and the tasks to be solved in the GDR

...tion of nuclear energy; development of new materials and technologies for their production and processing; genetic engineering. Alongside with the extension of a uniform basis for the construction of electronic components, the production of highly integrated switching circuits and opto-electronic products, new variants in the areas of information, automation and laser technology, the GDR, on the basis of a co-ordinated programme, will, for instance, give increasing attention to the development and manufacture of special technologies and equipment and of specific groups of components, computers, etc.  

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As regards the main trend 'automation', this applies, for instance, to the production of specific manufacturing systems, to various types of robots, ranges of control devices, drives, sensors and component groups on the basis of uniform standards. In co-operating in the partial programme 'New Materials and Technologies for their Manufacture' the GDR contributes the results, experience and knowledge gained in the plasma and electron-beam technology, as well as in the application of high-vacuum and laser-beam techniques, and will also participate in the production of new ceramic materials, of catalysts, micro-crystalline and amorphous metals, highly pure materials, plastics and elastomers.

These and other tasks to be solved by the national economy require a concentrated and, at the same time, far-sighted application of the existing scientific potential. That is why an annual average increase of 9.2 per cent in the funds allocated for science and technology is envisaged in the period 1986-1990, i.e. to more than 150 per cent by 1990 as compared with 1985. In the same period the potentialities of the scientific academies, of the universities and similar institutions, and of the combines in industry and other economic areas need to attain a 'new quality and render considerably higher results'. In the field of research the following trends of development are, above all, predominant:

- Information processing and technology, among them, above all, the development, application and improvement of CAD/CAM systems.

- Development and application of highly integrated switching circuits in microelectronics and opto-electronic component parts for application in light pipe and laser technologies.

12 Bericht des Zentralkomitees den XI. Parteitag der SED, op. cit., p. 56.

Creation of flexible automation variants by using third generation robots and fully integrated measuring and control engineering.

Highly productive techniques for the material-saving use of lignite, oil and natural gas; the industrial use of microbiological substances and genetic engineering, for the production of new highly refined products, above all in the sphere of carbonic chemistry and for the production of materials on the basis of local raw substances.

New energy-saving techniques producing a maximum of materials out of raw substances; techniques for the retrieval of basic metals and chemicals out of secondary raw material and the introduction of direct recycling by applying genetic engineering.

Application of genetic engineering, above all of genetic, immune, enzyme and cell culture technologies and of bio-reactor and chemical engineering for the production of high-quality products in the pharmaceutical and food industry, for a more effective livestock farming and crop production, as well as for the production of protein fodder.

Extended application of nuclear energy; production and storage of hydrogen and biological gas as sources of energy; new effective processes of energy conversion and research in new electro-chemical primary and secondary sources of energy.

The results obtained from scientific and technological research serve in many ways the modernization and reconstruction of the national economy: in the consistent tapping and application of local reserves of raw materials and fuel; to obtain a high degree of refinement of available raw substances and materials; to improve the quality of products and to guarantee a high product innovation rate; to increase exports and the productivity of foreign trade. Application of new knowledge helps to ensure the saving of material and financial assets and the concentrated use of investments for the rationalization of production.

This is the basis on which the economic preconditions are created in connection with the corresponding extension and modernization of
The development of scientific and technological research in the GDR and its implications in the field of training

the industrial consumer goods production, permitting the extension and improvement of the areas of social reproduction, essential for ensuring a varied and cultural life to all citizens by making full use of the most advanced findings of science and technology. Table 17 shows some of the targets set in the Five-Year-Plan to improve social and cultural conditions of the people.

Table 17: Selected targets in regard to the development of material and cultural standards in the GDR in the Five-Year-Plan period 1986-1990(a)

<table>
<thead>
<tr>
<th>Target/rates of increase</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction and modernization of dwellings</td>
<td>1 064 000 dwellings</td>
</tr>
<tr>
<td>of which new buildings</td>
<td>591 000 dwellings</td>
</tr>
<tr>
<td>Reconstruction of places of work</td>
<td>1 300 000 work_places</td>
</tr>
<tr>
<td>to improve working conditions</td>
<td></td>
</tr>
<tr>
<td>Increase in the net income of the population (annual average)</td>
<td>4%</td>
</tr>
<tr>
<td>Retail trade turnover (annual average)</td>
<td>4%</td>
</tr>
<tr>
<td>including: industrial goods</td>
<td>5.3%</td>
</tr>
<tr>
<td>food</td>
<td>2.7%</td>
</tr>
<tr>
<td>Consumer services (annual average)</td>
<td>5.1%</td>
</tr>
</tbody>
</table>


During the period 1986-1990, 485 thousand million Marks are earmarked for the continuation of this political course, namely to ensure stable consumer prices for basic commodities, rents, fares and services, for the construction, modernization and maintenance of dwellings and for provision of the growing requirements of the population in
The initial social conditions and the tasks to be solved in the GDR

terms of public health, social welfare and a varied intellectual and cultural life. Out of this sum, 86 thousand million Marks will be made available in 1987.\footnote{14}

The areas of science and education are of great importance for the solution of the far-reaching economic and social tasks; that is why the Five-Year-Plan covering the period up to 1990 makes also high demands on these fields. The targets set in this respect will be described in the following chapters.

\footnote{14 The figures for 1987 were compiled on the basis of data provided by E. Höfner, Umfangreiche Mittel des Staates garantieren allen Bürgern soziale Sicherheit (Extensive Public Funds guarantee Social Security to all Citizens). in: Neues Deutschland (Berlin) 28 November 1986. p.5.}
Chapter 2
Science policy and the system of research and development

2.1 The orientations of research and development

Science and technology have become decisive sources for an increase in efficiency in all areas of the national economy and, consequently, also for the further gradual elevation of material and cultural standards. "The key for essential improvements in the efficiency of the national economy in the eighties lies in a notably higher impact of science and technology on economy".\(^{15}\)

Science policy in the GDR is therefore marked by a continuous promotion of science, with demands on science increasing at the same time. Science policy is, on the one hand, regarded as an instrument of social policy intended to provide ever more adequately for the increasing requirements arising in regard to working and living conditions, leisure time, the protection and preservation of the environment, social security, qualification and cultural life. Apart from their instrumental importance for economic policy, science and education, on the other hand, have also an original value. As integral elements of the socialist way of life and culture and as essential aspects of the personality of a new type of man, science and education are not only the means but also the target of this policy. The close connection between science and social policy creates impulses conducive to the operational capability and the commitment of scientific workers and engineers. The

Science policy and the system of research and development

notable absence of anti-scientific and technophobic currents in the GDR is an expression of this progressive attitude towards science. In the view of public opinion, science and technology are positive values. The general targets of science policy are the following:

- Efficient utilization of the existing research and development potential for higher practical effectiveness of the results of scientific work.

- Concentration of scientific work on main fields of scientific and social development by considering the specific international and national conditions and development requirements.

- Setting higher scientific standards for research tasks and results which should be measured against world standards.

- Recognition in time and follow-up of qualitatively new and promising trends of work.

- Interdisciplinary co-operation at a high level in regard to the individual disciplines and better co-operation between the institutions of research and development.

- Command of the correlation between pure and applied research, development, design, investments, production, as well as the sale of the products.

These general targets were characterized by S. Schiller, the Deputy Director of the Manfred von Ardenne Institute in Dresden, with the following formula: 'Faster, better, more, and, above all, more effective'. As regards the fulfilment of the targets set by the Five-Year-Plan for the GDR's national economic development, decisive contributions are expected from science and development:

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- In the development, testing and application of new high technologies.
- In the renewal and improvement of existing equipment and technologies.
- In product innovation to the effect that 30 per cent of industrial products need to be innovated every year.
- In the rise in labour productivity, in the saving of labour (500 to 600 million working hours every year) and in the reconstruction and modernization of approximately 1.2 million places of work until 1990.
- In the saving of raw substances and materials, of energy and in decreased expenditure on transport operations.

This will lead to a further acceleration of scientific and technological progress in the national economy.

Essential contributions on the part of science are, above all, expected in the development and introduction of key technologies. By key technologies we understand those high technologies which, to an optimum, respond to economic conditions in the GDR and the utilization of which paves the way for constant economic growth. Key technologies with particular relevance for the GDR are:

- Microelectronics, above all new switching circuits and optoelectronic component parts.
- Computer technology (equipment of places of employment with office and personal computers and the creation of about 90,000 CAD/CAM work stations).
- Automation techniques (flexible automated production systems, a more intense application of industrial robots and microelectronic equipment of machine tools).
- Genetic engineering for medicine, food production, agriculture, upgrading of raw materials and the reduction of ecological damage.
Science policy and the system of research and development

For the GDR, being a country with very limited raw material resources but with a highly advanced industry, these key technologies are suited to building a research- and intelligence-intensive industry. This implies high demands on scientific workers, but also on the combines which, as the most important structural unit of industry, need to have a greater share in fixing the research targets and in applying the research findings for new products and techniques geared to market requirements, i.e. high demands on the innovation capabilities of the combines.

After detailed discussions and deliberations in the respective scientific committees the main trends for research and development, on which the scientific and technological potential needs to concentrate, were decided upon at the Xlth Congress of the Socialist Unity Party of Germany (see chapter 1, section 1.2).

This orientation confirmed a concentration on those lines of research which, by considering the specific conditions of the GDR, on the one hand, and general modern trends of scientific development, on the other hand, are suited to ensure maximum effectiveness for the entire society, whilst at the same time guaranteeing continuous economic growth, full employment and stable prices for basic consumer goods and analogous services, even under complicated international commercial conditions. Special attention is drawn to the promotion of basic research which is carried out at the Academy of Sciences and at the universities and similar institutions. Scientific and technological basic research is conducted within the scope of six research programmes which are under the overall control of the Academy of Sciences and higher education. They comprise the following programmes:

- mathematics, mechanics and cybernetics;
- physics and material research;
- chemistry;
- biological science;
- engineering sciences.
The development of scientific and technological research in the GDR and its implications in the field of training

The programmes on basic research are sub-divided into main lines of research, which are again classified into a great number of subordinated lines of research. A central and trend-setting document entitled ‘Concept for the long-term development of scientific, mathematical and technological basic research until the year 2000’ has been placed at the disposal of those in charge of basic research. This kind of basic research has been entrusted with the task of achieving a scientific heads-tart, permitting the preparation of top performances in important economic branches. Such State-approved concepts for basic research have, for some time, been updated for every new Five-Year-Plan period. In deciding upon the nature of basic research, there has been great continuity over many plan periods. Basic research has been assigned the task of creating a multitude of new findings, thus permitting the conduct of applied research at a high level. The GDR attaches great importance to the synthesis of basic and applied research, i.e. in the process of obtaining new findings, the targets and tasks of research also need progressively to take shape in terms of the practical application of the research results. What is needed are scientific top performances which also yield adequate economic results.

2.2 The potential of research and development

Research and development dispose of a large and efficient potential destined to achieve the aims arising in this field. Above all, in the sixties and seventies, when all highly industrialized countries considerably expanded their research potentials, the GDR also progressively increased the funds allocated to science and technology. There was a considerable rise in the numbers of those employed in science and development, particularly university graduates (see Table 18). Expenditure on science and technology at present amounts to approximately 5 per cent of the national income, and the proportion of those employed in research and development is about 2.5 per cent of all employed.17

The figures in Table 18 reveal that the GDR ranks among the world's leading highly industrialized countries, both in terms of the proportion of employed in research and development in the entire national economy and in the share of the expenditure on science and technology in national income. Yet it should not be overlooked that, as far as the quantitative aspect is concerned, the research and development potential of the GDR is only of minor importance in comparison with international figures. The proportion of the GDR in the world's research and development potential is about 1 to 2 per cent. This implies the urgent necessity for making the best use of the existing potential and of concentrating on those lines of research which are of major relevance to the country. That is why the long-term programme of co-operation with the USSR and the other socialist countries in the field of science and technology is of outstanding importance for the
The development of scientific and technological research in the GDR and its implications in the field of training

efficiency of the relatively small potential available. Co-operation with the scientific potential of the USSR is particularly close. Yet the GDR also aspires to extending scientific and technological co-operation with highly developed Western capitalist countries and to arrive at contractual forms of co-operation with them. This might also be a contribution to the reduction of confrontation and to the solution of bilateral and global problems.

The scientific potential of the GDR is largely concentrated in the Academy of Sciences, the universities and similar institutions and in the research and development centres attached to the combines. Even though this institutional differentiation is not fully identical with the differentiation of the types of research, such as basic research, applied research and development, the research work undertaken at these institutions nevertheless strongly concentrates on one specific type of research. The Academy of Sciences and the universities and similar institutions are mainly responsible for basic research. However, they are not confined to basic research only, but rather aspire to dedicating about half of the potential to basic research and the other half to activities related to the practical application of the results of basic research.

At the institutions attached to the combines, activities related to production and applied research and development are predominant, but neither are these institutions exclusively assigned to a definite type of research. There are aspirations to the effect that the combines provide more capacities for the construction of basic research units oriented towards specific industrial branches. The combines are rendering ever growing contributions in this respect. For instance, at the combine Carl Zeiss Jena, one of the leading producers of optical apparatus with long-standing traditions, 15 per cent of the research potential are used for strategically important basic research programmes. This enterprise can therefore combine science and production and maintain its position in the market (see chapter 4, section 4.6).

In the GDR, about two-thirds of the potential of specialists in science and development are concentrated in industrial establishments. In the seventies, the setting-up of industrial combines as efficient economic units also led to a concentration of the research and develop-

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18 K. Hartmann. Schlüssel für kräftiges Wachstum zum wohle des Volkes (Key for a Vigorous Growth for the Benefit of the People), in: Einheit (Berlin) 1986, p. 594.
Science policy and the system of research and development

ment capacities in industry. Before that time a great number of specialists in research and development worked at independent institutions under different authorities, more or less isolated and often without any organic connection with industrial production. Then the combines started pooling the existing capacities, which were oriented towards solving tasks arising at the enterprises, and rapidly expanded their potential of specialists and the technological foundations for research. In 1980, approximately 130,000 persons were employed in the research and development departments of 129 centrally administered combines. This figure is equivalent to 4.7 per cent of all employed at the combines.¹⁹

The research and development centres attached to the combines are fully integrated into the reproduction process of the enterprises. This means that preconditions for a rapid and widespread application of the scientific and technological results in practice have been created. As regards the size and the efficiency of the research potential of the individual combines, there still exist considerable differences at present. These differences can partially be explained by historic development. The branches of electrical engineering or chemistry, for instance, which emerged in the context of the industrial revolution have, for a long time had their own efficient research centres, whereas other branches, by tradition, lacked a major scientific potential of their own. Today we are facing a situation in which some of the leading combines, such as Carl Zeiss Jena, or Robotron, an enterprise of the computer branch, already have research and development centres at their disposal, where 12 to 15 per cent of the employees are working. At other combines such capacities are still in the process of construction.

Another important development trend in industrial research is that many combines are constructing their own capacities for basic research geared to their specific branches. Apart from production as the main process, the combines will henceforth also handle all preparatory and follow-up processes ranging from basic research to the sale of the products. The combines are thus able to comply with their responsibility as the most important link in the process of economic reproduction. In the context of this development, the potential for research and develop-

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ment will also in future continue to grow at the enterprises.

The Academy of Sciences and the universities and similar institutions also expanded their potential considerably during the past years. In 1984, the Academy had 22,500 employees, and 25,000 persons worked in the research and development departments of higher education. In the seventies the fixed assets were more than doubled. At the universities and similar institutions, research is combined with the training of students on the basis of the principle of the unity of teaching and research. This implies a considerable increase of the potential; it is estimated that the student research potential is about 40 per cent of the entire research potential in higher education.

One of the reasons for this increase in the potential of the Academy of Sciences and higher education institutions was to improve practical application of research findings in an attempt to ensure a smoother transition from basic research to industrial practice. Different organizational forms have been developed for this purpose, all of them dealing with complexes run with close co-operation between industry and an institute of the Academy or a university department; that is why they are called university-industry or Academy-industry complexes. The technological facilities of such complexes are jointly financed, and both employees of the Academy or the university and of the respective combines work there. Such joint complexes include laboratories, pilot installations, experimental workshops, application centres and a research and pilot establishment (Technikum). All activities carried out at these centres are aimed at the application of the results of pure research in industry. The 'Technika' are institutions equipped with the latest technology and which, apart from the testing and the research in new production techniques and scientific apparatus construction, are also envisaged for the modern training of students and for the further training of the scientific and engineering staff of the enterprises.

The forms of co-operation between employees in basic and applied research are extremely varied. Co-operation goes even as far as demonstrated by the following example: Berliner Werk für Fernsehelektronik (Berlin Works for Television Electronics) and the department of electronics of Humboldt University in Berlin started operating a joint

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research department in 1982, which has always been run by a university lecturer.21

In 1986, this institution already comprised 48 employees including 21 from Humboldt University and 9 from the Technical University of Karl-Marx-Stadt. This joint research department, inter alia, achieved the following results from 1983 to 1985:

- decrease of prime costs of the enterprise by 3.39 million Marks;
- saving of 335,000 working hours in production;
- 35 patents;
- one patent enabled the fully automated production of infra-red components and yields a profit of 8 million Marks.

The rapid growth of the potential also facilitated the extension of the departments of scientific apparatus construction attached to the Academy of Sciences and to higher education. This led to further improvements in the technological foundations of research and to less dependence on imports of research apparatus from abroad, which is all the more important in the face of the embargo policy of the USA. In establishing groups of users working with large scientific apparatus the existing research technology could be used more efficiently, and expenditure on the extension of the technological foundations could be decreased. The existence of a highly productive scientific apparatus construction in the GDR has a favourable effect on the extension of the technological foundations of research. As can be seen from Table 19, in this field the GDR ranks among the leading countries of the CMEA.

Due to the efficiency of scientific apparatus construction and, above all, as a result of the initiatives launched by the individual universities and similar institutions in an attempt to produce their own scientific apparatus, researchers have a relatively large stock of such equipment at their disposal. Yet enormous efforts will be necessary to provide also in the future for the rapidly growing requirements of

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Table 19: Volume of exports of the CMEA countries in scientific apparatus and laboratory equipment (in million roubles)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>GDR</td>
<td>56.6</td>
<td>69.7</td>
<td>121.0</td>
<td>173.0</td>
<td>398.0</td>
<td>572.0</td>
</tr>
<tr>
<td>Hungary</td>
<td>11.8</td>
<td>25.1</td>
<td>45.7</td>
<td>92.7</td>
<td>244.0</td>
<td>231.0</td>
</tr>
<tr>
<td>Poland</td>
<td>3.1</td>
<td>6.9</td>
<td>27.9</td>
<td>60.4</td>
<td>124.0</td>
<td>168.0</td>
</tr>
<tr>
<td>USSR</td>
<td>16.8</td>
<td>25.2</td>
<td>40.0</td>
<td>62.6</td>
<td>89.1</td>
<td>100.6</td>
</tr>
<tr>
<td>Czechoslovakia</td>
<td>12.2</td>
<td>14.7</td>
<td>30.2</td>
<td>44.1</td>
<td>70.9</td>
<td>90.8</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>0.3</td>
<td>1.3</td>
<td>4.4</td>
<td>26.4</td>
<td>55.8</td>
<td>92.2</td>
</tr>
<tr>
<td>Total</td>
<td>101.8</td>
<td>142.9</td>
<td>269.2</td>
<td>459.2</td>
<td>981.8</td>
<td>1254.6</td>
</tr>
<tr>
<td>In %</td>
<td>100.0</td>
<td>140.0</td>
<td>264.0</td>
<td>451.0</td>
<td>964.0</td>
<td>1232.0</td>
</tr>
</tbody>
</table>

Source: G.Kröber, Faktoren, die die Qualität der Forschung in den sozialistischen Ländern beeinflussen. op. cit., p. 86.

modern research technology.

It is already certain that in the coming years the rapid growth of the entire potential of scientific specialists cannot be continued at the same pace as in the past; this is, among other things, due to the fact that the number of employed in the national economy will not continue to grow. The age-groups with a low birth rate who will enter professional life in the future set natural limits to a further extension of this potential. This means that the general trend towards a more intense and effective use of the existing overall potential also increasingly applies in regard to the area of science and technology; yet it should be underlined, in this context, that structural changes in favour of the innovative proportion of the potential of scientific specialists—i.e. of highly productive research specialists—also need to be ensured in this phase. This is an urgent requirement and an essential precondition for the preservation and development of a highly productive scientific potential. Professional mobility of research workers, i.e. the capability for flexible adjustment to new requirements, change of research area.
change of job, research institution and territory, is also becoming increasingly important.

2.3 Management and organization of research

The division of labour between the potential of the Academy of Sciences, higher education institutions, and the combines, urgently requires specific regulations in regard to co-operation in the field of research. This type of co-operation is carried out on the basis of economic contracts concluded between the general directors of the combines and the rectors of the universities and similar institutions or the directors of the respective departments of the Academy of Sciences. These contracts enable the establishment of close relations between science and production and economic interlacement of these two areas. The parties conclude both long-term co-ordination agreements, giving strategical orientations for co-operation in the long run, and concrete performance contracts on the immediate achievement of individually fixed research targets. (See section 2.5 for a description of the main principles of this policy and the organization of science at the present stage of development).

The main areas of co-operation in the field of research are fixed in these co-ordination agreements, and joint projects are decided upon which are intended to assist co-operation effectively in the long run. They can comprise the following projects:

- Joint conceptional work on the strategies of research and development, including production and sale.

- Construction and joint use of jointly administered institutions (research and pilot establishments, laboratories, etc.), provision and utilization of research installations, equipment, etc.

- Provision of apparatus, materials and workshop facilities by the combines in an attempt to ensure the technological foundations of research at the institutions of the Academy and of higher education.
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- Exchange between research workers of the Academy or the universities and experts in science and engineering of the combines.

- Agreements on the practical training of students, co-operation of students in teams of young researchers in industry, assignment of the themes for the final theses, etc.

In the performance contracts, concrete research projects are agreed upon. The institutions of the Academy or of higher education are obliged to carry out the agreed research in accordance with the stipulations of the contract as regards application, quality and time. The combines co-operate in the elaboration of the research results. That is why the performance contracts include agreements about:

- Research aims and the form of the results.

- Deadlines for the most important stages of the work.

- Technical parameters and economic results to be achieved.

- Prices and the conditions for the granting of extra charges.

- Duties of the combines in regard to this co-operation (for instance, provision of apparatus and installations, utilization of the apparatus and installations of the combine by the co-operation partner, provision of specialists, testing of intermediate results and utilization of the final results in the combine).

- Protection of secrecy, freedom from defects in title and patent rights.

Co-operation in the field of research is laid down within the plans of the combines, as well as in the plans of the Academy or of the higher education establishment. The system of research contracts is to the advantage of both partners. It serves both the advancement of science and increases efficiency of the national economy.
2.4 Planning and financing of research

In the GDR, the planning of science and technology is integrated into the State economic planning system, which is under the responsibility of the State Planning Commission, the competent central State authority in this respect. Planning is carried out on the basis of:

- Fixed intervals of time (five-year plans or annual plans).
- The level of planning (State plan for science and technology as the central plan, and the plan for science and technology of a combine as a plan at a subordinate level).
- The planning institutions (plans of the institutes attached to the Academy of Sciences, of universities and similar institutions, etc.).

The State plan for science and technology is an instrument destined to exert central influence on important crucial targets of scientific and technological advancement. It comprises projects that are of importance for the State as a whole. The government's orders are the most important integral parts of the State plan for science and technology; they serve the assertion of important innovative processes that are significant for the entire national economy and which have a profound impact on the increase of its efficiency. Government orders, in all their components, are handled as a uniform whole, ranging from basic research and the subsequent research stages to the practical application of the results in production. In this process the co-operation between various ministries, individual institutes of the Academy of Sciences and departments of universities and similar institutions needs to be co-ordinated. Government orders have absolute priority, and that is why either a general director or a research director of a combine or, in the case of especially important orders, a deputy minister is entrusted by the respective responsible minister with their management.

The Ministry of Science and Technology is in charge of the preparation of the content, the elaboration and control of the State plan. The other ministries or the leadership of the Academy are responsible for the fulfilment of the partial tasks within the scope of their duties. The combines draw up their own plans of science and technology, which contain both the tasks laid down within the plan decided by the
next authority above them and the scientific and technological aims to be achieved on their own. The combines, therefore, receive concrete instructions from the State Planning Commission or through the respective ministries concerning the economic targets to be achieved in regard to the saving of labour and material, quality of the production, etc. The combines, for their part, are in charge of achieving these targets through scientific and technological measures. It is therefore necessary to discuss the plan with the involvement of all parties concerned.

Basic research is planned by the Academy of Sciences and the Ministry of Higher and Technical Education within the scope of the elaboration of the Five-Year-Plan or the annual plan for pure research.

The targets set in regard to research co-operation with the combines are laid down both within the plan for basic research and the State plan for science and technology, in an attempt to assert an interlacement between the two.

Research is financed both by the national budget and the respective customers, i.e. the combines. Basic research, which is carried out within the scope of long-term research programmes is, as a rule, financed out of the national budget. As regards more complex targets within the State plan for science and technology that are of relevance to various industrial branches, the Ministry of Science and Technology is in charge of financing the respective fixed targets. Research, however, is increasingly financed by the combines in line with the stipulations fixed in the above-mentioned agreements.

2.5 The co-ordination of research: some suggestions

(This section is based on a Decision of the Council of Ministers of the GDR which covers the basic principles of science policy and economic policies to link research in higher education institutions and the Academy of Sciences with the scientific and technological potentials of industry).

The accelerated international development of the productive forces calls for the increase of the rate of national development, thereby reaching the necessary level of labour productivity. Leading positions

must be won in decisive areas. This applies in particular in regard to
the key technologies, which are to a growing extent becoming the basis
of economic advance. This requires the organic combination of sciences
and production, which mainly takes place in the combines in the
planned economy of the GDR. In the coming phase of intensification,
important innovations are necessary, which can only be brought about
by basic researches going far into the future. We need research which
can lead to top-class achievements in science and technology and which
could give far greater economic yields.

The relations between the combines, the Academy of Sciences and
institutions of higher education must be greatly extended. Research
work at the Academy and in higher education should largely be in
conformity with the requirements of the economic, technical and tech­
nological development of the combines.

1. Research co-operation between the combines of industry and
the Academy of Sciences, universities and similar institutions must be
fixed in binding economic agreements on the basis of the plan. The
types of agreements used should be the long-term co-ordination agree­
ment on the development of research co-operation in general and the
achievements agreement for the different concrete research projects.

The co-ordination agreements should, firstly, define the main areas
of research co-operation, in order to create stable foundations by means
of joint strategies of scientific and technical development, for contrac­
tual co-operation in concrete tasks of basic and applied research.
Secondly the co-ordination agreements should stipulate measures of
effective and long-term support of the research co-operation in the
specific projects laid down within the achievement agreements. This
applies in particular to:

- Projects for the construction and joint use of technology and
  laboratories; the acquisition and effective use of research equip­
  ment, and the setting-up of pilot plants, so that technically and
  technologically applicable research findings could be achieved,
  ensuring a fruitful effect of the research work of combines, insti­
tutions of the Academy and of higher education establishments,
  and with a view to more rapidly making available new products
  developed at workshops or laboratories.
The development of scientific and technological research in the GDR and its implications in the field of training

- Provision of equipment, materials and workshop capacities by the combines for the material and technical guarantee and rationalization of research of institutes of the Academy and of higher education establishments.

- Exchanges of specialists and qualification measures, in order to make the research specialists of Academy and university institutions more familiar with the requirements of the economic and technical development of the combines, and, on the other hand, to impart to the research workers of the combines the latest results of natural science and technological research.

- Inclusion in the co-ordination agreements between combines and establishments of higher education of stipulations concerning practical training of students and integration of students in teams of young research workers of the combines, diploma thesis subjects for students on projects of the combines and other scientific problems.

2. Achievement agreements should be concluded for the different concrete tasks of research co-operation. The basic principle in this respect should be the economic advantage to both partners arising out of the fulfilment of the agreements. The agreements should be precise in their formulations, so that they clearly define the rights and obligations of both partners in the accomplishment of the tasks. The combines are basically the contractual partners of the institutions of the Academy and of higher education establishments.

3. Research co-operation should be envisaged within the framework of the plans for science and technology of the combines and in the Five-Year-Plan for Basic Research of the institutions of the Academy of Sciences and of higher education establishments. The plan should stipulate that the greater part of the scientific research potential of the Academy of Sciences and the university institutions should be applied within the scope of economic agreements on projects of the combines, in a phased process up to the year 1990. The Five-Year-Plan for Basic Research should envisage:
Fulfilment of the most important national economic tasks of systematic basic research and applied research defined within the agreements with the combines. Furthermore the plan should lay down the potentials as a whole which should be included in the research plans of the institutions, linked with the tasks of the combines.

The tasks of reconnaissance basic research to create the preliminary conditions for long-term projects within the scope of the main directions of research.

Tasks for solving complex national economic overlapping problems of the State Plan for Science and Technology.

Selected tasks accomplished for the users of areas outside the industry concerned.

At the combines the research projects of the Academy and the university institutions stipulated by the agreements should be included in their plans for science and technology. Co-ordinated tasks of the Five-Year-Plan for Basic Research and the plans for science and technology of the combines should ensure that the targets of basic and applied research should be fixed in accordance with the requirements of production, that the results should systematically be made available for the development of top-class products and technologies, and be utilized in production quickly and with high economic yields.

The research and development capacities of the combines should be reinforced for the creation of the preliminary conditions of scientific research in line with the requirements of long-term developments of achievements. At the combines, the funds envisaged within the plan should be used for providing the necessary material and personnel prerequisites for the rapid and effective introduction of research co-operation results in production.

4. The planned research co-operation should be annually redefined in the plans of the combines. Representatives of the Academy and the establishments of higher education should be invited to take part in the consultations of combines and competent industrial ministries on service offers of the combines.
5. The financing of research work of the Academy and the universities and similar institutions should be envisaged, on the basis of the Five-Year-Plan for Basic Research and the plans for science and technology, as follows:

- The main way is payment by the combines on the basis of contractual relations.

- For reconnaissance basic research, the Academy of Sciences and the Ministry of Higher and Technical Education receive State budget allocations, as before.

- For complex national economic overlapping tasks of the State Plan for Science and Technology, the Ministry of Science and Technology finances research tasks in specific areas from the State budget.

The payment of research tasks by the combines basically takes place after completion and defence of the results, and dependent on the achievement accomplished.

6. Agreed prices for the payment of research by the combines should be defined and included in the achievement agreements to be concluded in future.

7. To stimulate high achievements, the funds for material rewards of scientific institutions should basically be created in accordance with the results attained in research work. The research bonuses additionally won for top-class achievements and surpassing targets should be used for:

- additional contributions to the bonus funds;

- the rationalization of research work;

- the purchase of rationalization means from the rationalization means construction of the combines.
The personal material interest of scientific workers in great creative achievements in the solution of tasks within the scope of research co-operation should be increased, dependent on attainments, by the application of bonuses for achievements in connection with specific tasks of the Academy of Sciences and the institutions of higher education. In higher education, the stimulation of good research work in specific tasks should also ensure that the tasks in learning, training and education should be accomplished at a high level.

From the funds, the means available to general directors should be used to a greater extent for material rewards in recognition of great creative achievements of scientific workers of the Academy of Sciences and the institutions of higher education in the accomplishment of contractual tasks of research co-operation.

The President of the Academy of Sciences of the GDR and the Minister of Higher and Technical Education can grant target bonuses for the accomplishment of tasks of great social and national economic importance in basic research for the creation of a long-term scientific preliminary foundation, financed by the State budget.
Chapter 3
The system of education and scientific potential

3.1 Science policy and fundamental objectives of educational policy

The policy of social development in the GDR attributes considerable importance to the advance of science and technology. It is expressly formulated as a political objective that the acquisitions of the revolution in science and technology should be linked with the advantages of the socialist conditions of life. It is neither assumed that socialist conditions would automatically lead to a high standard of scientific and technical development, nor, vice versa, that the development of science and technology for its part would automatically bring about progressive social conditions. What is needed is the active attitude of individuals and the society as a whole.

The educational policy of the GDR has always pursued the aim of achieving this active attitude towards the development of science and technology, and to ensure that man should master technology, not be mastered by it. Some basic aims of educational policy have been pursued systematically for decades:

- It is endeavoured to achieve a high standard of education and culture for the whole population, because this is the most general prerequisite for the active development and utilization of progress in science and technology.
The system of education and scientific potential

- The situation originating from previous social conditions, with the overwhelming majority of workers and peasants having no formal qualification, had to be improved. The scientifically substantiated vocational or professional training for all has now been largely achieved.

- Elementary technological knowledge and experience in productive work should become a normal component of general education for all young people, and gradually of each citizen. The access to technological knowledge should thereby be facilitated, and an emotional aloofness towards technology should in this way be avoided.

- General education and all vocational or professional training should be developed in such a way that they should form a basis for subsequent augmentation or modification of acquired special qualifications. The aim here is the acquisition of a high degree of professional mobility, essential in conditions of accelerated scientific and technical development.

- Finally, the integrated system of education should be flexible enough to spot the respective inclinations and talents of young people and to promote them in an appropriate way. Education should encourage personal activity and promote creative attitudes.

These very comprehensive aims could only be achieved gradually, despite a great concentration of social forces on education, and even at present and in the future further efforts to develop education will be necessary. The events in the history of the GDR over the past four decades have confirmed the correctness of this basic orientation. The preparation for work directly in the field of science and research is closely linked with the described general orientation of education towards the development of science and technology, in fact so closely that it is impossible to give an isolated presentation of the specific selection, training and promotion of specialists for scientific and technological research and development. There are a number of reasons for this.
One of the foremost tasks in regard to the advancement of science is to recognize talent and to arouse interest in scientific work. Naturally a large number of young people need to be interested, and observed, in order to be able to discover their specific aptitudes. However, in the field of technology, these often become apparent only in the practical utilization of technology, i.e. through instruction at polytechnics—compulsory for all children and young people--, through school instruction in mathematics and natural sciences, and also through the basic instruction for students at the higher education level. The better the quality of teaching, the more likely that those having an aptitude for scientific work will be noticed.

Another reason is the wide range of qualifications at present required in research and development. A glance at the qualification structure in this area will reveal that highly qualified specialists of all grades—from specialists with a technical education to the highly skilled worker—are employed in a very large number of professions and disciplines. In most cases, it cannot be clearly stated whether a vocational or professional training would prepare participants exclusively for work in research and science, or only for practical technical and similar purposes. That is why the general standard of education and training must be high, if highly qualified specialists in science are to be formed.

Finally, training and education are social processes, concerning people, young citizens of the State, with constitutional rights and obligations and very varied social backgrounds and motivations. As pointed out above, it is not enough to discover the talented, their interest in science must be stimulated. Although in the preparation for work in science and research individual endeavours and continuous individual work are necessary, it must nevertheless be admitted that a direct individual preparation of young people from school up to university graduation is only possible in exceptional cases. Perfectionist ideas about educational planning are particularly unrealistic in this field. As a rule adequate numbers of able young people should be trained, from among whose ranks the scientific specialists will eventually be recruited. Those trained in such a way, and who will then choose other professions or occupations, will certainly not have been trained in vain: society needs talent in all fields of life.

The preparation of young people for work in science and technology therefore plays a large part in the overall promotion of interest in the development of science and technology, which is of course
supported and complemented by specific measures, to be described at
greater length in the following sections.

3.2 Socialist reform of education and the system of
education

At the beginning of the sixties an important educational reform
was begun in the GDR, the programme of which was passed as law
after several years of public discussion. In the preamble to this law, it
is stated that the requirements of science and the revolution in tech­
nology, the conscious application of the economic laws of socialism, and
the development of the socialist community, of democracy and culture,
mark the features of human formation in our time. It is emphasized
expressly that these objective requirements call for an education and
training adequate to the modern standard of science and technology.

The core of that reform, which in general set out to create an
educational system for the advanced socialist society, has in the mean­
time been implemented, namely:

- Transition to the 10-year general polytechnical secondary school
  for all young people (previously 8-year elementary school).

- Occupational training for all young people before entering
  working life, i.e. training as a skilled worker or as a specialist
  with a completed technical college education or higher education;
  efforts were concentrated on the comprehensive development of
  vocational training for skilled workers.

- Polytechnical instruction was included in the programme of
  general education. It was conceived as an equal component of
  socialist general education. Like all other components of general
  education, it serves the comprehensive preparation for adult
  social life, especially for working life, but it is not a direct course
  of vocational training.

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23 Gesetz über das einheitliche sozialistische Bildungssystem (Law on the
Integrated Socialist System of Education), Teil 1, No. 6, 1965, p. 83.
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$TI = \text{Technical institutions (Fachschule)}$

$UL = \text{University-level institutions}$

$VT = \text{Vocational training}$

$VTA = \text{Vocational training with } 'Abitur'$

$ES = \text{Extended secondary school}$

**Figure 2:** Educational flow diagram, 1984
As already stated, the objectives of the educational reform have been achieved. At present approximately 85 per cent of a generation of young people successfully complete the 10th class of secondary school, another 8 to 9 per cent leave school after the 8th class. Vocational training is today largely based on completion of the 10th class, but leavers of the 8th class may also go on to complete a vocational training. At present approximately 93 per cent of all young people of one age-group acquire a completed occupational training in one level (see Figure 2).

The successfully accomplished reform of education has created essential conditions for the active participation of citizens in modern scientific and technical development. An integrated socialist educational system has been built up, which should, according to all present estimates, remain valid in its basic structure until the coming millennium. Partial corrections of the system are not excluded, and they are taking place even at present. Integration does not mean uniformity, nor rigidity. A glance at the system will reveal its multiplicity. Uniformity above all relates to its objectives—above all to the aim of education as regards socialist personalities. The principles of the development of the system and the throughgoing nature of the system, which leaves no margin for dead ends, allowing for transition from school to all further levels of education, are also comprised in this uniformity. Finally the concept of the content of education, the relationship between general and specialized education, and similarly the relationship between general and vocational or professional education and training, are also uniform. The strict separation of general and occupational education and training, characteristic of the German educational system of the past, has been overcome. Vocational or professional training is a continuation of general education received at the high school; at the same time general education is continued within the scope of all vocational or professional training courses, where it is consolidated. Both kinds of education are always closely interlinked so as to impart to young people sound foundations for facing life.

Figure 3 shows the present system of education of the GDR. As in Figure 2, the different types of technical education may be recognized. It always starts on completion of the 10th class. The training of nurses, nursery staff and junior school teachers directly follows up on the 10th class of high school and then extends over three to four years. Other training courses, such as those for engineers, economists and agrono-
The development of scientific and technological research in the GDR and its implications in the field of training

Figure 3: Integrated socialist education system of the GDR, 1985
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**Figure 4:** Integrated socialist education system of the GDR, 1992

VTA = Vocational training with 'Abitur'
PC = Preparatory course
PPT = Preliminary practical training
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mists, also require the previous completion of a vocational training, and then extend over three years.

The modifications in the system of technical education and higher education will be discussed in the following sections 3.3 and 3.4. Once these modifications have been fully implemented the educational system will then have the structure shown in Figure 4.

3.3 The general polytechnical secondary school

3.3.1 Form and content of secondary school education

Attendance at the 10-year secondary school has been one of the elementary rights and obligations of all GDR citizens since 1974. The Constitution stipulates that: “In the German Democratic Republic, there is universal 10-year compulsory secondary school education, to be complied with by attendance of the 10-class polytechnical secondary school of general education.”

The setting-up of the 10-class secondary school was a complicated process prepared gradually over several decades and its implementation demanded considerable economic efforts on the part of the society. Before the general introduction of the secondary school for all, the one-class rural schools had to be abolished; in 1945-1946 there were 4,114 schools of this kind, 668 in 1949-1950 and by 1960-1961 none.

This was only possible through the construction of a system of central rural schools, which for its part required the provision of a system of school-bus transport for the children. The concept of central schools was linked with the concept of agricultural development: as a rule central schools were established in villages where machine and tractor stations had been set up, so that a network of central villages was formed.

24 Prior to 1974 the duration of compulsory schooling was eight years.


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Table 20: Transition from the 8th to the 9th class (1951-1980)

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of pupils</th>
<th>% of leavers of the 8th class</th>
</tr>
</thead>
<tbody>
<tr>
<td>1951</td>
<td>36 100</td>
<td>11.5</td>
</tr>
<tr>
<td>1965</td>
<td>153 900</td>
<td>72.0</td>
</tr>
<tr>
<td>1975</td>
<td>241 100</td>
<td>91.6</td>
</tr>
<tr>
<td>1980</td>
<td>225 100</td>
<td>92.9</td>
</tr>
</tbody>
</table>

Source: Das Bildungswesen der DDR, op. cit., p.51.

Preliminary forms of the present secondary school had been created as early as the fifties (then known as ‘10-class schools’ and ‘middle schools’); after the reform of education the present type of secondary school became the predominant type. Table 20 shows the transition from the 8th to the 9th class between 1951 and 1980.

Today the 10-year compulsory secondary school has in practice been realised. Only a very small number of pupils leave school after the 8th class. They too receive a vocational training as skilled workers, which lasts three years.

The secondary school offers a general education, preparing young people for life in the socialist community in all its variety of forms, including working life. The content of general education is subject to continuous revision and adjustment to the advancing standards of science, culture and other fields of human activity, in an endeavour to develop an all-round education. The following subjects are indispensable in modern socialist general education: mother tongue, mathematics/natural sciences, technology and economics, social sciences, foreign languages, literature, art and physical training. As can be noted from Table 21, each of these subjects is adequately represented in the programme of general education.

The secondary school is composed of:

- junior level: classes 1 - 3
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Table 21: Representation of different fields of education in the 10-year general secondary school of the GDR

<table>
<thead>
<tr>
<th>Field of Education</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics, natural sciences</td>
<td>29.8</td>
</tr>
<tr>
<td>Introduction to socialist production and productive work</td>
<td>10.6</td>
</tr>
<tr>
<td>Social sciences, German, literary and arts subjects</td>
<td>41.6</td>
</tr>
<tr>
<td>Foreign languages</td>
<td>10.6</td>
</tr>
<tr>
<td>Sports</td>
<td>7.9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Source: Das Bildungswesen der DDR, op. cit., p. 55.

- intermediate level: classes 4 - 6
- senior level: classes 7 - 10.

At the junior level, the subjects taught are: German, mathematics, handicrafts and school gardening, music, drawing and sport. Preparation for polytechnical education takes place at this level, and pupils acquire elementary technical and economics knowledge.

At the intermediate level, natural sciences, social sciences and foreign languages are added, taught by specialist teachers. Mathematical and natural science knowledge and practical skills are acquired in the lessons in mathematics, biology, physics and handicrafts.

The senior level completes the high school education. It creates the conditions allowing for decisions concerning the selection of the future occupation and further education. Specialized instruction is fully developed at this level. In natural sciences, the subjects chemistry, astronomy and geography are added; mathematics and German acquire particular importance. Polytechnical education is continued with the subject 'Introduction to socialist production', associated in the teaching programme in particular with mathematics and natural science. As
from the 7th class the pupils start productive work in socialist enterprises of industry, building and agriculture. Work takes place according to specific plans and assumes above all educational functions, but it is conducted in real production conditions so that the pupils are directly involved, alongside the workers, in the fulfilment of the production plan, the innovation movement, etc. An endeavour is made to entrust them with work which they accomplish independently.

Polytechnical education could only be developed in its present form because the nationally-owned enterprises took on the responsibility for the systematic training of the pupils. Since the beginning of the eighties more than 5,000 enterprises have provided instruction for approximately 850,000 pupils, taught by approximately 8,000 full-time and 22,000 part-time instructors and skilled workers. This type of instruction is seen as vocational preparation, but, as already pointed out, it is a component of general education and not premature vocational training for skilled occupations.

In the brief description of the secondary school of the GDR, we have intentionally presented in greater detail the importance given to mathematics, natural sciences and polytechnical education. These subjects account for a total of about 40 per cent of the entire time devoted to instruction. Without overestimating the quantitative aspects, this proportion clearly indicates the endeavours of the country to ensure a sound preparation of youth for life in this age of revolution in science and technology. Also to attain a high quality, all instruction in mathematics, natural science and the theoretical part of polytechnical education is assured by specialist teachers trained in institutions of university level.

Apart from the predominant standard type of 10-class secondary schools, there are special schools for the handicapped and also special classes and schools for the promotion of particularly gifted pupils. The special schools are highly developed. In many cases they lead handicapped children (blind, deaf and physically handicapped) up to vocational training and even to higher education; they also promote mentally handicapped children to the furthest possible extent.

The tasks of special classes and the wide system of extra-mural school working-groups, which complete school instruction, will be dealt with at greater length in the following chapter.

27 Ibid. p. 61; and Statistical Yearbook of the GDR 1985. p. 294.
3.3.2 Promotion of gifted pupils at the high school and during the period of school attendance

The 10-year school of the GDR, as already underlined above, is a general education school. This fact is not altered by its polytechnical nature, but, of course, it reinforces preparation for a subsequent vocational or professional training. This also applies in regard to the preparation of pupils for subsequent work in science. The school endeavours to recognize specific gifts and to promote them from an early stage.

As early as 1965, the Law on the Integrated Socialist Education System, passed that year, stated:

"The socialist education system offers to all citizens the opportunity to develop their gifts and talents... With the elevation of educational standards of all those learning, measures must be taken for the promotion of specific gifts and talents."\(^{28}\)

Since then, a very many-sided system of measures and institutions for the promotion of those pupils who show particular gifts and talents has been developed. This is based on the guarantee of a high standard of scientifically substantiated education for all. It is the essential prerequisite for allowing each child to reveal specific gifts, to test inclinations and to let talents become apparent. The increased efforts of recent years for the recognition and promotion of outstanding talents—with the declared aim of the long-term guarantee of future top-class achievements in science—is not understood as an alternative to a high standard of education for all. The promotion of the highly talented forms part of the general effort to create the best conditions for the promotion of individual interests on the basis of a general education essentially similar for all.

This is made possible by a varied and graded system of additional educational options, structured in three levels:\(^{29}\)

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\(^{28}\) Gesetz über das einheitliche sozialistische Bildungssystem, op. cit., p. 85.

\(^{29}\) Helmut Klein, Die DDR fördert ihre Hochbegabten (The GDR Promotes its Highly Talented), in: Demokratische Erziehung. Pahl—Rugenstein Verlag (Köln) No. 9, 1985, p. 33.
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- Level 1: Individual work with all pupils of the entire high school throughout all levels.
- Level 2: Optional instruction at school, in working-groups and courses, or in working-groups outside school in various fields of science, the arts, technology, sports, etc.
- Level 3: Special schools and special classes for those with outstanding talents in various fields; scientific pupils' associations.

Level 1

Individual work with each pupil demands highly qualified teachers and an adequate number of teaching staff, which has been largely achieved in the GDR. Individual attention to pupils begins in the junior classes (1-3), coupled with the after-school centre; at this stage working-groups for pupils exist, conducted by qualified staff.

The promotion of talents is reinforced at the intermediate level through the introduction of special subjects, and then again in the senior classes. In the special subjects the different individual talents and inclinations are more clearly recognizable. Specialist teachers have a great responsibility for the promotion of such talents, which they can do by making differentiated demands on the pupils, as well as by means of the systematic utilization of promoting measures outside school instruction. Towards the end of high school attendance, pupils are directed towards future ways of vocational development in line with their respective specific talents.

Level 2

The uniform programme of instruction at the 10-year school provides the opportunity of optional subjects for senior pupils as from the 7th class. The main forms of optional instruction are lessons in a second foreign language as from the 7th class, and working-groups as from the 9th class. The latter, which have a skeleton programme, at present operate in 33 fields, e.g. practical mathematics, elementary statistics, electronic data processing, electronics, applied chemistry, microbiology, technological subjects, arts and music. All these working-groups are conducted in the form of courses; participation is voluntary. It is intended to start these courses at an earlier stage in future.
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Another wider range of working-groups and courses exists outside school. These are run by sports clubs, by the political organization for children (Thaelmann-Pioneers) and the Free German Youth organization (Freie Deutsche Jugend), and also the schools. During the school holidays 'Specialists Camps' are conducted, where games, sport and recreation are coupled with activities in the respective specific fields of interest. Various pupils' contests, such as 'Olympic' contests in mathematics, physics, natural sciences, foreign languages and music represent other important forms of such activities. Sports competitions in the form of Children's and Youth Spartakiades, with complete 'Olympic' programmes are particularly well-known events. It will be noted that at this second level the aim is to rouse interest among children and youth of the widest spectrum in specific fields, offering them opportunities to test themselves, to make them aware of their own particular gifts, and to develop their achievements. The discovery and promotion of those gifted in science is not the exclusive aim, but young people with talents in that direction are observed and given particular attention.

Level 3

It may be expected that through the various activities at levels 1 and 2 the most gifted pupils meriting particular promotion will come to the fore. A specific system of working-groups with rising standards is available for such pupils. In the field of sports, the activities are conducted by the sports clubs. In scientific subjects, the Young Pioneers' Houses play an important part, assisted by scientific workers. The scientific pupils' associations are also at an advanced stage. Thus the Pupils' Natural Science Association in Berlin, presided by Professor R. Herrmann of the Humboldt University, recently celebrated its 10th anniversary. It covers the subjects of biology, chemistry and physics, and has approximately 1,000 members in the Berlin area. The Pupils' Mathematics Association 'Leonhard Euler' in Berlin (500 members) is headed by Professor J. Nietzsch, also of Humboldt University. Scientific workers of the Academy of Sciences also assist the pupils' associations.

In addition to these working-groups for the planned promotion of highly gifted pupils there are special classes and special schools with emphasis on various fields, ranging from sports and music to the different areas of science. In the field of music such special classes are
above all associated with singing-groups of international rank, such as the Thomaner-Chor (Leipzig) and the Kreuzchor (Dresden). The promotion of young sports champions is only conceivable in special schools or special classes, in view of the particular requirements of training, instruction and leisure. The main reason for the creation of these specific educational establishments, above all in the field of science, is the fact that particularly gifted pupils can hardly be adequately encouraged at the general high schools after a certain stage of development of their talents.

Instruction in specific classes and special schools for gifted pupils follows the general prescribed teaching programme for all high schools, but with more intensive training in certain specific subjects. Institutions of higher learning and scientific research institutions, as well as combines with a production programme involving particularly intensive scientific research, exert a marked influence on these schools. The Carl Zeiss Jena combine runs a specialized school with a concentrated programme in natural sciences and technology; universities run special classes (11th and 12th classes) in mathematics. As a whole the experience acquired in these classes and schools is positive.

It should be added that in the guidance and advice to pupils concerning the choice of their further education after completing the 10th class of the high school, their specific inclinations and talents should be taken into due consideration. Young people who show ability for a scientific specialization are directed towards continued education at an extended secondary school or to a course of vocational training with 'Abitur', both leading to university entrance standard. This will be dealt with in section 3.6.

3.4 The training of skilled workers

The qualification of a skilled worker (Facharbeiter) is that acquired, through the system of vocational training, by the large mass of the working population of the GDR. The certificate of skilled qualification, which is issued at the end of that training, marks the conclusion of that level of education. It surpasses the scope of the training of workers in the traditional sense, although their occupations constitute the core of that training and those who acquire a certificate of skilled worker represent the majority of those trained at this level. Within the system
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of vocational training, however, young co-operative farmers, employees in trade and administration, and others also acquire the certificate of skilled workers. This accounts for the high proportion of those with a completed vocational and professional education, which, as explained above, according to the Constitution of the GDR should be acquired by every young person prior to entry into working life. In the course of recent decades the vocational training system experienced a planned development.

Table 22: Proportion of newly qualified skilled workers among the respective age-group, 1960-1985

<table>
<thead>
<tr>
<th>Year</th>
<th>Age-group(^1) in 1 000 persons</th>
<th>Newly qualified in 1 000 persons</th>
<th>Proportion (in %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>278</td>
<td>126</td>
<td>45.0</td>
</tr>
<tr>
<td>1965</td>
<td>189</td>
<td>108</td>
<td>57.0</td>
</tr>
<tr>
<td>1970</td>
<td>262</td>
<td>159</td>
<td>61.0</td>
</tr>
<tr>
<td>1975</td>
<td>259</td>
<td>172</td>
<td>66.0</td>
</tr>
<tr>
<td>1980</td>
<td>289</td>
<td>209</td>
<td>72.0</td>
</tr>
<tr>
<td>1985</td>
<td>246</td>
<td>183</td>
<td>74.0</td>
</tr>
</tbody>
</table>

\(^1\) 18-19 year old persons of the population in the requisite year

Source: Calculated according to the Statistical Yearbook of the GDR 1962 to 1985.

Part of the young skilled workers continue their education at the next higher levels (see sections 3.2, 3.5 and 3.6.), and can go as far as completing higher education. The qualification as skilled worker can be acquired by young people immediately after the completion of their general education, but those already employed can qualify by attending courses without interrupting their professional activity. This second method played a role of greater importance in the past, when there were still large numbers of workers who had not completed vocational
training (see Table 22). The proportions changed as vocational training immediately after the completion of general education was extended, as can be seen from Table 23.

Table 23: Acquired certificates of skilled workers in the GDR, 1965-1985 (in 1,000 persons)

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
<th>Apprentices</th>
<th>Employed</th>
<th>Proportion of apprentices (in %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965</td>
<td>197.8</td>
<td>108.3</td>
<td>89.3</td>
<td>54.8</td>
</tr>
<tr>
<td>1970</td>
<td>260.5</td>
<td>159.4</td>
<td>101.1</td>
<td>61.2</td>
</tr>
<tr>
<td>1975</td>
<td>257.3</td>
<td>172.1</td>
<td>85.1</td>
<td>66.9</td>
</tr>
<tr>
<td>1980</td>
<td>264.8</td>
<td>208.6</td>
<td>56.2</td>
<td>78.6</td>
</tr>
<tr>
<td>1985</td>
<td>229.6</td>
<td>182.6</td>
<td>47.0</td>
<td>79.6</td>
</tr>
</tbody>
</table>

Source: Statistical Yearbook of the GDR 1986, p. 298.

At present, young people who obtained their certificate of skilled worker immediately after the completion of their vocational training account for approximately 80 per cent of all qualification certificates acquired at this level. Employed persons, who account for the remaining 20 per cent having obtained this certificate, had previously been either without a completed vocational training, or they were trained in a second trade—which increasingly gained in significance.

3.4.1 Structure of trades at the level of skilled worker

Workers in the GDR are trained in a large number of skilled trades. For these trades there is a binding standard State catalogue (Systematik der Facharbeiterberufe) which defines a number of apprenticed trade-groups:

- 238 occupations for secondary school-leavers after the 10th class;
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- 62 occupations for secondary school-leavers after the 8th class (see section 3.2. above);
- 8 occupations apprenticed in adult vocational training courses;
- 50 rare crafts trades for secondary school-leavers after the 10th class;

among the 238 occupations mentioned under (i) above, there is a group of 86 in which vocational training is combined with preparation for the 'Abitur' (see also section 3.6).

The largest proportion of skilled workers are trained within the scope of the first group of occupations. This includes approximately 100 so-called 'basic occupations', to which we shall come back further on. These courses as a rule extend over two years.

The second group, for school-leavers after the 8th class, comprises 62 occupations, but with a smaller number of apprentices. These occupations are not very demanding in regard to theoretical capabilities; courses last three years. This category was introduced because there are young people who fail to complete the 10th class and not because there are jobs with lower intellectual requirements.

The third group comprises occupations which can for obvious reasons only be practised by adults, e.g. drivers. Frequently, this is a second profession.

The rare crafts trades, at present approximately 50, are only apprenticed to small groups of young people, as will be understood by some examples: sail-makers, cartwrights, lace-makers, cutters of precious stones, picture casters, makers of musical instruments, dressmakers or tailors, glass-blowers, porcelain painters (duration of training up to four years). These are trades involving specific techniques or products, maintaining old traditions and continuing historically valuable crafts. Generally these occupations are of significance for the fostering of cultural traditions and for specific requirements. Some are also of importance as highly skilled workers in science, e.g. glass-blowers.

30 See section 3.2., Figure 2: approximately 64 per cent of an age-group of young people at present take up vocational training after the 10th class, only 7 per cent after the 8th class.
In the last group, vocational training with 'Abitur', university entrance standard and a skilled worker certificate are acquired in three-year courses at special enterprise trade schools. The 86 selected occupations of this group can also be learnt through standard vocational training courses for skilled workers lasting two years (without 'Abitur').

The volume of training in the different occupations is planned in accordance with national economic requirements. The courses for apprenticeship in the different trade-groups of necessity have a varying frequentation. Table 24 presents a survey of proportions between the different trade-groups.

This table requires some explanation: The total number of apprentices decreased for demographic reasons, yet the proportion of apprentices in the respective age-groups remained unchanged. That is why as a rule the numbers of certificates issued in the different trade-groups also decreased.

In some fields, however, this trend does not prevail; here the share of apprentices in the total number has increased and there is even a certain amount of growth. The main cause is the significance of certain occupations for the development of science and technology. These occupational fields include automation technology, data processing and electronics, where the training of skilled workers almost doubled its share in the total numbers from 1980-1985. It should be noted, however, that the proportion of these 'modern' occupations with a high growth rate is not great.

A number of other occupations have increased their proportion in the total number, although they are not among those that are decisive in regard to science and technology. Here the cause lies in the age structure of those employed in agriculture, which needs a large supply of young workers to maintain the number of employed. Demographically conditioned requirements of the reproduction of manpower of this kind always influence the necessary training structures.

As has been pointed out, occupations of specific significance for the advance of science and technology were conspicuous for their high growth rate, but as a rule did not show any larger numbers. This is a common international feature.

In an investigation by the U.S. Department of Labor, for example, with statements on projections of employment for 1995, it was pointed out that occupations with the largest job growth overwhelmingly
The development of scientific and technological research in the GDR and its implications in the field of training

Table 24: Certificates of skilled workers obtained by apprentices in selected trade groups 1980 and 1985

<table>
<thead>
<tr>
<th>Trade-group</th>
<th>Number (in 1 000)</th>
<th>Proportion (in %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All trades</td>
<td>208.6</td>
<td>100.0</td>
</tr>
<tr>
<td>Including:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Chemistry</td>
<td>4.5</td>
<td>2.1</td>
</tr>
<tr>
<td>- Machines, apparatus, equipment</td>
<td>42.0</td>
<td>20.1</td>
</tr>
<tr>
<td>- Manufacturing and processing technologies</td>
<td>15.1</td>
<td>7.3</td>
</tr>
<tr>
<td>- Electrotechnics/electronics:</td>
<td>15.0</td>
<td>7.2</td>
</tr>
<tr>
<td>share of electronics:</td>
<td>1.8</td>
<td>0.9</td>
</tr>
<tr>
<td>- Automation technology;</td>
<td>3.4</td>
<td>1.6</td>
</tr>
<tr>
<td>share of data processing</td>
<td>1.4</td>
<td>0.7</td>
</tr>
<tr>
<td>- Textile, clothing, leather</td>
<td>11.6</td>
<td>5.6</td>
</tr>
<tr>
<td>- Building</td>
<td>27.2</td>
<td>13.1</td>
</tr>
<tr>
<td>- Agriculture, forestry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Fishery</td>
<td>13.5</td>
<td>6.6</td>
</tr>
<tr>
<td>- Economy/administration</td>
<td>17.6</td>
<td>8.4</td>
</tr>
<tr>
<td>- Trade, catering, services</td>
<td>25.3</td>
<td>12.1</td>
</tr>
</tbody>
</table>

included occupations accounting for only a small share of the employed. This applies in particular, in regard to those of great significance for the development of science and technology. Here the largest group among the 40 occupations with the largest job growth is that of electrical and electronic technicians, envisaged to grow by 60.7 per cent from 1982-1995, but the increase of which will only account for 0.9 per cent of the total job growth. Among computer service technicians the growth in employment is estimated at 96.8 per cent, but this occupation does not feature among the 40 occupations with the largest job growth.  

Evidently there are several explanations of this phenomenon of apparently very fast growth of 'modern' scientific and technical occupations, coupled with their moderate numerical volume. For one thing, many new and very important technological developments are still only beginning to penetrate into the national economy. On the other side, the generation of new occupations is only one means, and obviously not quantitatively the most significant of appropriate reaction on the part of manpower to modern scientific and technical developments. A quantitatively far more important factor is the transformation or completion of the content of existing occupations. Therefore, occupation strategies must be adjusted, and those of the GDR have been doing so for a long time.

3.4.2 Trends of content development in vocational training

The constantly changing demands in regard to the content of occupations and hence to vocational training were observed with attention. For decades the principle has been asserted that future skilled workers should receive a comprehensive basic education followed by a vocational specialization. The aim is a high degree of professional mobility and the ability to change and extend personal qualifications by means of further education in case of need or motivated by interest to take up a different occupation.

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The plans regarding the content of occupations are subject to constant revision; in the course of the present Five-Year-Plan up to 1990, training programmes for all occupations are to be revised. Thus, all apprentices are introduced to the significance and fields of application of microelectronics; problems of informatics and automation are treated in a phased programme (see chapter 5). For occupations in the food industry, the chemical industry and agriculture, fundamental knowledge of biotechnologies will be included in the future.

In recent years, 'basic occupations' were introduced in the GDR. This means a basic vocational training in a larger group of allied occupations, with a high percentage of general knowledge and basic vocational skills, as a foundation for subsequent occupational specialization. At present 100 out of 238 occupations for which vocational training is provided to school-leavers after the 10th class are basic occupations, offering prospects for subsequent specialization in 392 possible occupations. These basic occupations comprise all mass occupations, so that roughly 50 per cent of all apprentices receive a basic training with modern content and a specialization. Their basic vocational training, combined with the sound foundation of general knowledge acquired at the 10-class general secondary school, enables them to acquire other specializations within their basic occupation-group in a relatively short time.

3.4.3 Practical procedure of vocational training

The vocational training system is State-controlled and directly subordinate to the authority of a State Secretariat. The practical training takes place at nationally-owned enterprises of all economic branches, at agricultural and trade co-operatives, and—particularly in the case of the rare crafts trades—under the guidance of individual crafts masters. The theoretical part of vocational training generally takes place on two days a week at trade schools, with those of the nationally-owned enterprises catering for the majority of all apprentices. Municipal trade schools exist for occupations with smaller numbers of apprentices.

At the nationally-owned enterprises a large part of the practical training takes place at apprentice workshops; during the later phases of the training this is transferred to production departments of the relevant work process. There the apprentices are under the guidance of
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instructors, who are advised by the teachers generally responsible for the practical vocational training. At present more than 100,000 workers are employed as apprentice instructors.

Great importance is attributed to the active, creative participation of apprentices in the accomplishment of national economic tasks. The socialist vocational emulation takes place in all enterprises; the best achievements, new developments, etc., are shown at the 'Fairs of Tomorrow's Masters' (Messe der Meister von Morgen), and the best of these exhibits are presented at an annual central show.

During recent years apprentices and young skilled workers have increasingly been included in teams of young research workers, which include young scientific specialists of the research and development departments of combines and enterprises. The number of economically effective accomplishments or innovations by apprentices are considerable and continue to increase. The effect of this on the personality development of the young workers, farmers and employees is evident.

In an attempt to summarize the main aspects of the vocational training of skilled workers in the light of the subject of the present investigation, the following statements may be made:

- A high standard of vocational training for skilled workers has been achieved, allowing them to take up an active position in the face of the requirements of the advancing development of science and technology.

- A high degree of vocational mobility has been attained, which is being applied in practice.

- The applied system of vocational training facilitates the transition to other, primarily similar occupations, and promotes life-long education.

- The field of research and development can at all times provide for its requirements out of the totality of skilled workers in the various occupations. The necessary extension of qualifications is accepted as normal by the workers concerned.

- As a whole the foundations provided by the 10-year school and the high quality of the vocational training system may be
regarded as the generally positive attitude towards the progress of science and technology and the absence of fear in regard to this development amongst the population of the GDR.

3.5 Technical college education

There is a well developed system of technical colleges in the GDR, which makes an important contribution to the training of highly skilled specialists for the national economy. Technical college graduates work in practically all branches of the national economy.

Technical colleges had a long-established tradition even in the days of capitalist Germany. In the 18th and 19th centuries, technical colleges arose with the beginning of industrialization, the development of public education, the health and social welfare services. Very often they developed on the basis of existing vocational training centres and similar educational institutions; at the same time they developed alongside the universities and similar institutions, except for rare exceptions. After 1945, a number of new technical colleges were founded, including schools of engineering in different branches, such as chemistry, building technology, agricultural technology, energy supply, mechanical engineering, educational training colleges, and medical colleges for health service workers. Today there are 239 technical colleges of various kinds, including 90 colleges of engineering.

In the course of this development, two types of technical colleges arose. The first type requires the completion of the 10-year secondary school by those admitted for a course extending over three or four years. It comprises an extended practical training in accordance with the requirements of the respective professions, which takes place at a corresponding enterprise or institution. This type of training is characteristic of more than 60 technical colleges of medicine, more than 50 educational training colleges (junior school teachers, educational workers), and 10 technical colleges of art.

The second type of technical college requires the completion of the 10-year school and of a vocational training as a skilled worker. The courses mostly extend over three years. This is above all characteristic of the training of engineers, economists and agronomists. This second type of technical college represents a specific historic feature of educational development in Germany. According to the German educational
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ideals in the 19th century, institutions of higher education were not preoccupied with applied sciences, and they were not directed towards the satisfaction of practical requirements. Since the rapidly developing capitalist economy urgently needed large numbers of highly qualified specialists, capable of applying scientific knowledge in practice, a corresponding training was created at the level of technical education. At that level it represented a specific, very high stage of qualification, which required secondary-school level (10-year education) and a certificate of skilled vocational specialization with two years of practical training as a condition of admission, even at a very early period. In his function within the social division of labour, the technical college graduate in the field of technology was never a technician, but always an engineer and entitled to present himself as such.\textsuperscript{32} Specialists, internationally described as technicians, were also trained at technical colleges, but the duration of the courses was very much shorter.

In the same way as for technical education, there was also similar development in other fields of education and training. As a result there was a dual system of higher education, consisting of the institutional higher education at universities and the above-described sector of higher technical education. This dual system has been gradually changed since the end of the Second World War.

Towards the end of the forties and in the fifties, the training of teachers up to the 10th class, previously conducted at higher technical colleges, was transferred to university level as part of the school reform of that period. Up to that time only teachers for the 'Gymnasium', i.e. the high schools leading up to university entrance standard, had been trained at universities; their total number had always been small and they studied in similar courses as other specialists in their subjects, e.g. a future teacher of mathematics would study in the same way as a future mathematician. Thereafter the number of pedagogical students increased considerably; even in the fifties one student out of four undergraduates of universities and similar institutions was a future teacher. This made it necessary to separate the higher education of future teachers from that of future specialists in the respective subjects, i.e. the training of mathematics teachers from that of future mathematicians in research, economy, etc. The same applied in regard

\textsuperscript{32} Schools of engineering were described as 'institutes of higher technical training'.

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to the training of historians, specialists in German literature, philologists, etc. Training took place at the same institutions, with the same teaching staff, but with distinct ‘profiles’ dependent on the subsequent professional activity. Now, as in the past, the training of teachers for the junior school level took place at technical training colleges.

At the end of the sixties, there was a further change in technical education, this time in the training of engineers. In the interests of adjustment to the new demands arising from the progress of science and technology, a number of schools of engineering with a very high standard were transformed into ‘Ingenieurhochschule’ (university-level engineering colleges). They were to retain their practical orientation, typical of technical colleges, so that a completed vocational training remained the condition for admission; however, they were to become part of the system of higher education, so that university entrance standard became an additional prerequisite of admission.

Nevertheless the training of engineers and economists at technical colleges still occupies an important place. In 1985, 9.8 thousand engineers graduated from technical colleges of engineering, and 7.2 thousand from technical universities; for economists the corresponding figures were 8.3 and 3.2 thousand respectively. The total transfer of the training of these specialists to the level of higher education has already been decided and will become universal by the end of the eighties. Technical colleges will continue to train technicians in the internationally accepted sense of the term, as well as economic specialists of that level. The forthcoming changes will not affect the technical education of paramedical staff, educational workers, nursery nurses, etc.

As explained in detail above, the training at technical colleges in the past and at present has an orientation towards the practical application of knowledge in technology, economics, medicine, educational theory and other scientific subjects. This does not exclude that technical college graduates, in many cases engineers and economists, should be employed in research and development, closely working together with scientifically-trained graduate specialists. This applies in regard to laboratory assistants and technicians, pharmaceutical assistants, etc., directly trained in science for this activity. Part of the paramedical assistants are also needed directly in research work. A similar situation prevails in regard to documentalists, library assistants, etc., in social scientific research work.
Traditionally a considerable part of the engineers trained at technical colleges have been employed in construction and projection, but engineers are also performing very useful work in development. Altogether the ratio of university and technical college graduates in the fields of scientific and technological research and development (comprising construction and projection) is approximately 1:1. It will undoubtedly be understood that this was one factor motivating the intention to raise the standard of training for engineers in general from technical college to university level. Above all, in the fields of construction and planning, the CAD-systems give rise to radical developments in science and technology, which make such changes recommendable.

3.6 Educational level preparing for university entrance

In the GDR, university entrance standard (Abitur), or an equivalent certificate of education, is the basic prerequisite for higher education. This may be obtained in various ways:

- At the extended secondary schools (12 years), following up on the 10-year secondary school, ending with the ‘Abitur’ after two years.

- Through special vocational training courses ending with the ‘Abitur’, and with a qualification as a skilled worker; this vocational training with ‘Abitur’ takes three years.

- Through one-year preparatory courses for studies in technology or economics at technical universities for young skilled workers having completed the 10-year school; university entrance examinations in this case have an orientation towards certain subjects of study. Similar preparatory courses exist for preparing leavers of the 10th class for educational training courses.

- Finally, technical college graduates as a rule may be admitted to higher education. This applies without limitations to courses at technical colleges requiring the completion of the 10th class and a certificate of skilled specialization, such as those in technological sciences, economic and agricultural sciences. Technical college
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graduates of these disciplines as a rule select higher education in the same or related subjects, mostly through correspondence courses.

Table 25: Methods of acquiring university entrance standard, 1984

<table>
<thead>
<tr>
<th>Method</th>
<th>Number of graduates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extended secondary school (including special schools)</td>
<td>22 000</td>
</tr>
<tr>
<td>'Abitur' classes of vocational training</td>
<td>10 000</td>
</tr>
<tr>
<td>Evening schools</td>
<td>2 000</td>
</tr>
<tr>
<td>Preparatory courses at universities</td>
<td>3 000</td>
</tr>
<tr>
<td>Total</td>
<td>37 000</td>
</tr>
</tbody>
</table>

Source: Approximate calculation according to information in the Statistical Yearbook of the GDR 1985.

It is only logical that the kind of preparation for university entrance standard greatly influences the choice of subsequent professional work, including access to work in science and research. Leavers of preparatory courses, who had previously been skilled workers, tend to prefer technical disciplines with a practical orientation. The same applies in regard to those who complete combined courses of vocational training with 'Abitur', although many of these choose fields of studies having no relation to their apprenticed trade. Leavers of the extended secondary school with 'Abitur' tend more towards subjects with theoretical orientations; these, therefore, subsequently supply the larger part of university graduates finding employment in teaching and research. It should be emphasized that these are trends, not the result of official orders.
Table 25 shows the numbers of 'Abitur' graduates according to the different ways of acquiring entrance to university; to these numbers should be added those admitted to higher education after having completed technical college education leading up to university entrance standard. Since technical education and the qualification thereby acquired has a high social prestige, the number of those continuing their studies in higher education is not very large. In the technological, economic and agricultural sciences approximately 5 per cent of the graduates of corresponding technical colleges subsequently pass on to higher education, according to investigations by the authors. These mainly study through correspondence courses, in which they account for slightly more than half of the students enrolled.
Chapter 4
Higher education and the potential of science

4.1 The development of scientific and technological education

The training of specialists at the universities and similar institutions—as has been emphasized in this study—had already in the past been closely linked with research and oriented to the future employment of the graduates in science and research. This corresponded with the ideal of the unity of teaching and research in university training, as it was represented by Humboldt, which had a decisive influence on the modernization of the German university in the 19th century. This applied without restriction to training in mathematics and natural sciences at the universities and technical universities which were founded as from the 19th century. The development of a very efficient system of colleges of engineering and other technical colleges which, at the higher education level, train highly qualified engineers, etc. for the practical application of science, permitted the universities and technical universities to concentrate on the training and preparation of students for scientific and research work (see section 3.5).

When the GDR was founded this dual system was taken over. However, above all in the field of technical education, considerable disproportions became apparent. In the early fifties there existed only the Technical University of Dresden and two smaller colleges at university level, as compared with about 80 predominantly smaller schools of engineering. In mathematics and natural sciences, training was provided at all six universities of the country. This inevitably implied that enor-
mous efforts needed to be concentrated on technical education at university level. *Table 26* shows that this programme has been fulfilled with great consistency.

---

**Table 26:** Number of technical universities and university-level colleges of technology in the GDR

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1939</td>
<td>2</td>
</tr>
<tr>
<td>1951</td>
<td>3</td>
</tr>
<tr>
<td>1960</td>
<td>10</td>
</tr>
<tr>
<td>1970</td>
<td>19</td>
</tr>
<tr>
<td>1980</td>
<td>18</td>
</tr>
<tr>
<td>1985</td>
<td>18</td>
</tr>
</tbody>
</table>


---

As early as the beginning of the sixties, the number of institutions at university level for the training of engineers was increased to ten, which consequently led to a considerable rise in the number of graduates.

As can be seen from *Table 27*, since the early sixties almost every third university graduate has been a scientist or an engineer, to which should be added the teachers in scientific and technical subjects.

In the course of time the proportions in the training between graduate engineers (university level) and engineers changed in the same degree as the capacities of the technical universities rose. Also, the ten largest schools of engineering became university-level institutions in the late sixties. *Table 28* reveals the effects of this development.

As a result of the extension of the technical universities and colleges at university level, the proportions between engineers, on the one hand, and graduate engineers, on the other, shifted ever increasingly. In 1960 the ratio of engineers to graduate engineers was $3.5 : 1$ and in 1984 it was $1.3 : 1$. The scientific foundations for the training of engineers were continuously expanded. *Table 28* also reflects the proportions of engineers in the relevant age-groups, and *Table 29* gives an international comparison.
The development of scientific and technological research in the GDR and its implications in the field of training

Table 27: University graduates including those in science and technology, 1955-1984

<table>
<thead>
<tr>
<th>Year</th>
<th>All disciplines</th>
<th>of which:</th>
<th>Teachers in science and technology</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>science</td>
<td>technology</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(in 1 000 persons)</td>
<td></td>
</tr>
<tr>
<td>1955</td>
<td>7.6</td>
<td>0.57</td>
<td>0.54</td>
</tr>
<tr>
<td>1960</td>
<td>15.0</td>
<td>1.49</td>
<td>3.11</td>
</tr>
<tr>
<td>1970</td>
<td>22.3</td>
<td>1.13</td>
<td>5.01</td>
</tr>
<tr>
<td>1980</td>
<td>24.2</td>
<td>1.57</td>
<td>6.57</td>
</tr>
<tr>
<td>1985</td>
<td>25.0</td>
<td>1.46</td>
<td>7.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(in %)</td>
<td></td>
</tr>
<tr>
<td>1955</td>
<td>100.0</td>
<td>7.3</td>
<td>7.1</td>
</tr>
<tr>
<td>1960</td>
<td>100.0</td>
<td>9.0</td>
<td>20.7</td>
</tr>
<tr>
<td>1970</td>
<td>100.0</td>
<td>5.1</td>
<td>22.4</td>
</tr>
<tr>
<td>1985</td>
<td>100.0</td>
<td>5.8</td>
<td>28.8</td>
</tr>
</tbody>
</table>


The number of university graduates working in the fields of science and technology and their proportion in the number of employed is very high as a result of this large-scale training. On the basis of the data available, it can be estimated that about one-third of all graduates from institutions of higher education employed in the national economy are scientists and engineers. As compared with international standards, above all the number of graduate engineers is apparently very high. The deficit in such specialists, which the GDR was facing at the start of its socialist construction, has been overcome for some time now.

The same attention which has for decades been given to the numerical extension of higher education in the scientific and technical
Higher education and the potential of science

Table 28: Number of graduates in technology and as percentage of the relevant age-group, 1960-1984

<table>
<thead>
<tr>
<th>Year</th>
<th>Graduate engineers (1)</th>
<th>Engineers (2)</th>
<th>Total (1) + (2)</th>
<th>Engineers as percentage of age-group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>3 111</td>
<td>11 293</td>
<td>14 401</td>
<td>6.3</td>
</tr>
<tr>
<td>1970</td>
<td>5 011</td>
<td>15 263</td>
<td>20 274</td>
<td>11.1</td>
</tr>
<tr>
<td>1980</td>
<td>6 568</td>
<td>9 901</td>
<td>16 469</td>
<td>6.3</td>
</tr>
<tr>
<td>1985</td>
<td>7 196</td>
<td>9 802</td>
<td>16 998</td>
<td>6.3</td>
</tr>
</tbody>
</table>

Note: The percentage of the relevant age-group is calculated on the basis of one-quarter of the 22-26 year old population (i.e. a four-year age group) in the respective year.


subjects, also applies to the increase in the quality of the training provided. The respective activities carried out in the individual fields have always been very varied. Yet some fundamental orientations can be stated:

- Great importance is attached to a sound theoretical basic education; this applies both to natural and engineering sciences.

- Theoretical education is linked with providing practice-oriented knowledge. In this process a balanced proportion between fundamental knowledge and specialized education has always been aspired to.

- Mastery of the methodology of scientific work and the ability to carry out experiments with due competence is taught at the educational establishments.
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Table 29: Graduate engineers as a percentage of the relevant age-group

<table>
<thead>
<tr>
<th>Country</th>
<th>Graduate engineers 1977-1978</th>
</tr>
</thead>
<tbody>
<tr>
<td>United Kingdom</td>
<td>1.7</td>
</tr>
<tr>
<td>Federal Republic of Germany</td>
<td>2.3</td>
</tr>
<tr>
<td>Japan</td>
<td>4.2</td>
</tr>
<tr>
<td>United States</td>
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<td>(German Democratic Republic)</td>
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- Great importance is attached to the ability to carry out interdisciplinary co-operation; important elements of the related sciences are also studied.

- For a long time efforts have been made at the institutions of university level to reinforce students' participation in research work, to entrust them at the earliest possible stage of their studies with opportunities for individual work in order to promote their independence and creativity.

Over the past decades scientific contests among the students have seen a considerable upsurge. Since 1965, central exhibitions by students and young scientific workers have regularly taken place, at which they can present the results of their scientific work, as a rule under the
guidance of their teachers. This work is honoured by prizes awarded by
the Minister of Higher and Technical Education, the universities, and
other institutions, and discoveries protected by patents are no excep­
tions. All these contests are linked with the training, above all with
practical training and the system of assigned annual and diploma
papers. These efforts, which are intended to teach students to develop
their own activities, independence, and creative achievements at an early
stage, facilitate the discovery and promotion of talented students and
the choice of those who will later change over to scientific work.

4.2 Specific orientations of training to research—two
profiles of training in the engineering sciences

4.2.1 New ways of initial and further training of engineers and
economists

The need for a more rapid adaptation of higher education to the
social and economic changes in the GDR and to the growing pace of
scientific and technological progress developed as early as the sixties.
Science was introduced to ever larger areas of industry and agriculture,
social life and public administration. There was a rapid increase in new
demands on research and for the application of science in practice,
which implied an equally growing and differentiated need of the society
for scientifically-trained specialists. The pace and the diversity of this
process made high demands on the response of higher education,
whether it was the introduction of new fields of study, the moderniza­
tion of the curricula or a change in the enrolments for the individual
branches.

Higher education in the GDR has created its own mechanisms,
ensuring its response and adaptability to the necessary changes:

o In the sixties, standing scientific committees for all subject-groups
were set up at the Ministry of Higher and Technical Education
(at that time still a State Secretariat). These bodies advise the
Ministry on the preparation of decisions in regard to higher
education policy. They comprise leading scientists of the
branches typical of the respective subject-groups. One of the
central tasks of these committees is the updating of the curricula and the work on the nomenclature of the branches of study.

- Nationwide scientific methodological conferences for the basic fields of study are regularly held, which discuss the problems and tasks facing teaching and research in the individual areas.

- There was an expansion in the research on educational theory in higher education and the economics of education.

As a result of the social, scientific and technological development and the decisions taken in regard to higher education policy, higher education had developed a multi-form structure which was especially marked in the sphere of the engineering sciences. Engineers were trained in 86 different disciplines at universities, technical universities and university-level colleges of engineering, as well as in 104 disciplines at a considerable number of technical colleges at non-university level (see section 3.5).

At the end of the seventies the hitherto proven methods of adaptation of higher education were no longer able to respond adequately to the newly arisen situation. At that time it was no longer a matter of changing some curricula or constituting a new branch of study, but of changes of a more general nature. This new situation was above all marked by the following:

- Scientific and technological progress was increasingly determined by such key technologies which not only affected some production branches, but which in almost all economic branches led to fundamental changes. In nearly all economic areas, and at least in the engineering and economic sciences, this implied the emergence of new types of qualifications of those involved in the development and application of these key technologies.

- High qualification standards have been reached in all economic branches. The proportion of university and technical college graduates in the total number of employed was already extraordinarily high. Higher education needed to respond with greater flexibility to the new type of demands which had arisen from social, scientific and technological development. In future the
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demands on the professional versatility of the graduates will have
to be even higher. In this context, a great number of disciplines
and different levels gave rise to contradictions.

Growing technology and product innovations led to an obsoles­
cence of the knowledge of numerous specialists and increasing
needs for further education. The universities and similar institu­
tions, as well as educational centres attached to big enterprises
rapidly increased their offers for further education. This made it
possible to eliminate from the curricula highly specialized knowl­
edge that was becoming rapidly obsolete, yet, on the other hand,
required the development of a flexible scheme of further educa­
tion.

International scientific and technological co-operation was
increasingly gaining ground. Yet as far as the exchange of
students and trained specialists was concerned, a considerable
number of obstacles emerged as a result of the differences in the
training standards of engineers at technical universities and tech­
nical colleges. This differentiation still existed only in the GDR,
and led to problems in the determination of international equiva­
lents.

At the beginning of the eighties, these problems were still the focus
of attention in research on higher education and in the discussions
about higher education policy. On this basis a, concept for the struc­
ture of initial and further training of engineers and economists was
decided upon in 1983 by the Political Bureau of the Socialist Unity
Party and the Council of Ministers of the GDR. The fundamental
targets fixed in this concept with regard to educational policy imply
that:

- Only universities and similar institutions will in future provide
for the training of all engineers and economists.

- A differentiation in higher education based on two so-called
‘basic profiles’ will efficiently respond to the different activities
of engineers and economists in the cycle science-technology-
production and to the ensuing different demands on their knowl­
ext and attainments.
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The first of these basic profiles is intended above all to prepare students for activities in research and development, whereas the second is geared to the management and organization of production. The different targets pursued in the training in these two basic profiles need to be fulfilled by a differentiated structuring of the content and the methods of training, and consequently by the duration of the training:

- The necessity and the possibilities of in-service training of the graduates should be taken into consideration in the planning of the content of training, and in-service training should become even more systematic and effective.

- A new type of training of 'technicians' at technical colleges needs to be developed; the qualification standards of these specialists will correspond to the internationally prevalent level of technical education, namely the technician.

The above-mentioned resolutions of the Political Bureau of the Socialist Unity Party and of the Council of Ministers underline the joint responsibility of higher education and industry for the materialization of this concept. Priority has been given to co-operation in regard to the determination of the educational targets, and emphasis has been placed on the necessity to take into consideration both the long-term concepts of economic development and the economic strategies. Finally, all involved parties guaranteed that all changes would only be undertaken after thorough examination. At the beginning, only some universities started to test the new training concept in a few disciplines.

This gave rise to wide public discussion about the updating of higher education in the spheres of engineering and economic sciences, which, at the end of 1985, led to the adoption of further resolutions by the leadership of the Socialist Unity Party and the government on measures concerning the reorganization of initial and further training of engineers and economists. These measures are aimed at a gradual implementation of the above-mentioned concept by 1990.

An analogous concept for training in the fields of agricultural science and economics has also been approved in the meantime, and is at present being implemented at the universities and agricultural institutions of higher and technical education. This implies the complete abolishment of the dual system in higher education in the GDR.

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4.2.2 The two basic profiles in the training of engineers

Within the scope of the first basic profile, engineers are first and foremost trained to solve problems arising in pure and applied research, as well as for the development of new products and new manufacturing techniques; training in the second basic profile is aimed at qualifying engineers for the management, planning, organization and supervision of production. This is demonstrated by the example of engineers in the chemical industry. As already mentioned in chapter 1, in view of the economic conditions of the GDR, it is especially important in this industrial branch to:

- upgrade raw materials to a very high degree;
- use local raw substances, secondary raw materials and the by-products obtained in numerous manufacturing processes to the greatest possible extent;
- decrease the specific energy consumption and use secondary sources of energy;
- achieve a high degree of automation;
- ensure a high flexibility and reliability of all installations;
- protect the environment.

Many of the scientific problems to be solved in this respect are related to the technology applied in the chemical industry. This gave rise to the establishment of the discipline of 'process engineering', which meets the research orientations of the first basic profile. The graduates of this discipline work together with graduates of other disciplines. They should above all be able to cope with the following tasks in engineering:

- solve technological problems arising in thermic, mechanical and biotechnological processes, as well as in processes of reaction techniques by means of experimental and theoretical work;
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- work on system engineering and cybernetic problems arising in the investigation, modelling, simulation and optimization of processes and techniques;
- design completely new types of techniques or stages of techniques.

The graduates should therefore, above all, be employed in:
- research and development departments of the chemical industry (and in other branches where different types of process engineering are also of considerable importance, e.g. food industry, coal transformation industry);
- design and project departments of installation construction;
- scientific institutes of higher education and of the Academy of Sciences.

The future tasks and the most important areas of work of the graduates (the description of which can only be very general in this study) consequently determine the content of training. The ability to carry out research work aspired to in the first basic profile requires a broad theoretical training, above all in the basics of mathematics, chemistry, physics, engineering and social sciences. This general basic training needs to be so broad that future process engineers, throughout their working lives, will have the theoretical qualifications for their scientific work and for co-operation with representatives of other disciplines—such as physicists, biologists and economists. The students need to be able to comprehend the specific structures and ways of thought of the above-mentioned basic disciplines and to apply them independently. Since the present-day training is geared to future research activities, the basic training also comprises such elements of education which are at present not yet applied by the engineering sciences, but which could be of some importance for the development of completely new technologies.

The professionally-oriented specialized training builds up on this general basic training in mathematics and in the natural, engineering
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and social sciences. It imparts to the process engineer comprehensive knowledge in the spheres of physical chemistry, hydromechanics, thermodynamics, construction engineering, information processing, etc., thus enabling him to analyse, to model and to optimize techniques and manufacturing processes. The process engineer also acquires capacities for the design and operation of modern installations by applying modern computer technology, including the construction and the use of data banks and programme systems. Above all, in their last academic years, the students receive a specific specialized training. It deepens the basic training in diverse fields of study which, in the main, are offered on an optional basis. Further aspects dealt with are related to scientific management, ecology, economy and industrial safety, and the students complete a longer practical training in process engineering.

It will certainly be easier to understand the organization of the first basic profile of training being oriented to research, if the second basic profile is also demonstrated by the example of the chemical industry, i.e. the practical engineering and technological work of chemical engineers.

At the chemical enterprises it is important to organize production on a sound technological, economic, ecologically effective and scientific basis, to decrease the specific material and energy consumption and to streamline the existing techniques. For this reason, the discipline of 'chemical engineering' has been established. The graduates of this discipline need to be able to deal with the following engineering tasks:

° planning, organization and supervision of production with regard to the observance of optimum technological, material and energy-saving parameters by taking into account the needs of industrial safety and ecology;

° solution of tasks aimed at an improved quality of the products;

33 'Build up' indicates the correlation between the content and not the chronological sequence. Experience shows that the students are not motivated enough to acquire theoretical foundations if they do not clearly recognize its significance for their personal plans for the future.
co-operation in engineering and technological analyses on the condition of machines and installations;

• co-operation in the preparation and materialization of rationalization and investment schemes.

The graduates should be employed essentially as engineers and technologists in production.

As regards the academic content of the training of those engineers who are qualified to do research work, we rely on the many years of experience of the universities and technical universities. Within the scope of the subject-group of ‘mechanical engineering’ these institutions provided, for instance, training in disciplines of theoretical engineering, such as applied mechanics or hydromechanics and thermodynamics. In the subject-group of ‘electrical engineering’, there already existed the discipline of ‘theoretical electrical engineering’ with an especially marked orientation towards mathematics and the natural and engineering sciences.

The training of teachers for the secondary schools, as already mentioned above and in section 3.5, also provides very valuable experience in regard to the differentiation of higher education between a research and an application-orientated basic profile.

The examples given above clearly indicate that the planning of studies, i.e. the determination of the target, the content, the methods and the organization of all disciplines, is an especially complicated and responsible task. It can only be mastered to the required extent if the universities co-operate closely with the scientists and leading specialists working at the institutions and enterprises that will employ the graduates after completion of their studies.

The sharing of responsibilities between the involved universities and enterprises has proved its worth in this respect. On the basis of their concepts for the development of their technologies and products, the enterprises are above all entrusted with the task of specifying the future activities of the engineers, as well as the qualifications required for these activities. These documents, which are called ‘employment requirements’, have to be elaborated for all engineering activities or functions at the respective enterprise. The universities and the scientific committees attached to the Ministry of Higher and Technical Education are charged with the task of comparing these diverse employment requirements to new disciplines or academic professions and of
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Compiling those which are similar or closely related to each other. Other requirements arising from general social, scientific and technological development and being relevant to the knowledge and the attainments, to the consciousness and the behaviour of the future graduates, need to be taken into consideration as well.

We call the specification of all these elements ‘requirement characteristics of a discipline’ (at an international level the terms job description, qualification characteristics, job profile, job pass, specialist’s model are also in common usage), which include the description of the activity, the requirement description and the qualification description. The requirement characteristics are an integral part of all curricula, which also specify the individual subjects, their sequence in the course of studies and the methods and organizational forms of the studies.

By means of the following example we would like to briefly illustrate the co-operation between universities and enterprises. The Schwarze Pumpe combine (Schwarze Pumpe is the old name of a village surrounded by rich lignite fields) is at present introducing a new material and energy-saving technique to convert lignite (including low-quality saline lignite) into gas, which is not only destined for power generation, but also for the production of basic chemicals. The technique is a variant of high pressure gasification of pulverized coal. This leads to changes in the work of engineers and, consequently, to new qualification requirements. Until recently the upgrading techniques applied in such enterprises only included the briquetting and coking of lignite. The development and application of this new technique requires a far more profound knowledge, both on the part of those working in research and development and those organizing and supervising the production process. More profound and sound attainments and knowledge in the modern fields of thermodynamics and kinetics, of hydrodynamics and carbonic chemistry are necessary. Specialists of the gas combine specified the future activities ranging from the drying and fragmentation of the coal to the control of the gas transport, as well as the qualification requirements ensuing from this process and submitted them to the Bergakademie Freiberg (Mining Academy of Freiberg). This document was elaborated and submitted on the basis of a co-ordination agreement signed between the Bergakademie Freiberg and Schwarze Pumpe. The Mining Academy then established two new disciplines: ‘process engineering’ (which belongs to the first basic profile) and ‘coal upgrading’ (which belongs to the second basic profile).
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Approximately 130 co-ordination agreements, signed between universities or institutes of the Academy of Sciences and the combines or local administrations, are at present in force. These agreements, which are in the form of commercial treaties, state the type of co-operation and the reciprocal obligations in initial and further training, research, and their material and financial guarantees (see chapter 2, section 2.5).

4.2.3 Interdisciplinary problems in research-oriented training

An active acquisition of scientific knowledge on the part of the students presupposes that the studies become a more intense productive phase in the life of a young engineer or scientific worker. This can above all be achieved if learning is closely linked with the integration of students into research and the practical application of research results. The connection between the acquisition of scientific knowledge and the scientific work of the students requires that, in the course of studies, the relationship between university lecturers and students increasingly assumes the character of co-operation and partnership in joint tasks.

Only students with a strong motivation will, on their own initiative, develop activities whilst acquiring scientific knowledge. Motives, such as the use of the results of their own work for scientific purposes, for social progress and for a peaceful future, occupy an important place among students in the GDR. The development of such motives again presupposes that the student is convinced of the possibility and the necessity of preserving peace and that he recognizes this to be the only viable prospect for the future. Knowledge of history and about the conditions for social progress, war and peace, and cultural education, therefore form an indispensable integral part of socialist higher education.

Students are involved in scientific work in different ways: it starts at the end of the first academic year and continues throughout their studies. The curricula envisage various forms of scientific work, such as practical courses in laboratories, practical training for future engineers at chosen enterprises, the writing of assigned papers and of the thesis. The number of places for trainees provided by a combine and the tasks to be accomplished by the students are mostly fixed in the co-ordination agreements signed between universities and combines. Special attention
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is drawn to the fact that the work accomplished by the students is to the advantage of the enterprise, but that at the same time it also promotes the scientific qualifications of the students. The themes of the assigned papers and theses are decided in line with the same criteria.

Other forms of scientific work are above all conducted during the periods when no lectures take place, which is normally at the end of a term, i.e. before the holidays, so the students can carry out their independent scientific work. The use of this time is at the discretion of the individual students. It can range from intensive studies in foreign languages, the 'closing of gaps' in co-operation in research work at the university or the enterprise where they undergo practical training. The universities submit the respective offers to the students, and the groups of Free German Youth, existing at all universities, compile scientific programmes for the collective treatment of important tasks to be solved at the universities and combines. The universities are frequently entrusted with the solution of tasks arising in the field of scientific apparatus construction, where work is increasingly assuming the character of demanding scientific work. At the combines, 'youth projects' are taken on by the Free German Youth; they are mostly related to the development of specific technological solutions. The work on such tasks is stimulated by the socialist emulation and is frequently carried out in the form of contests and awards organized within the scope of the 'Fairs of Tomorrow's Masters' and the Exhibitions of Students and Young Scientific Workers (Leistungsschau der Studenten und jungen Wissenschaftler).

Another interdisciplinary problem arising in the organization of training is that the necessity for and the possibilities of further education of the future graduates need to be taken into consideration from the very beginning. Studies on the activities of engineers at the enterprises point out a marked differentiation. The young graduates are, as a rule, entrusted with very restricted tasks and functions, which we call the 'basic functions of an engineer'. On the basis of the experience gained in this phase, some of these engineers, after various years of professional practice, take on further tasks of a more complicated nature. These tasks either presuppose a more complex knowledge or more specialized attainments, and, for the most part, also involve greater responsibility. This differentiation leads to conclusions which are both relevant for the determination of the objectives of initial and further training and for a reasonable combination between initial and further training. The training needs to:
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- enable the young graduates to rapidly get used to the various basic functions of an engineer, and
- to continue their education throughout their careers.

On the part of the universities and similar institutions this, at the same time, requires the provision of an adequately varied and flexible offer of further training for the graduates so that they continue to be able to solve new and more complicated tasks. Such an offer should stand out by its interdisciplinary character and a close connection with the latest research trends. In this context, it should be pointed out that the new concept of training already devotes a good part to developing the ability of students to conduct interdisciplinary scientific work and to their introduction to research work.

Finally it should be mentioned that the planning of training is very closely connected with the planning of the future employment of the students. Research-oriented training only serves its purpose if the graduates will really be employed in research. This is why the employment of graduates is governed by law, which stipulates that one year before the conclusion of their studies, all students must be in possession of a contract guaranteeing employment in line with their acquired qualifications and other personal conditions.

These regulations also ensure that the future employment of the graduate is not decided by outsiders, but in consultation with the student. It is certain that in some individual cases not all interests can be taken into consideration, and that compromises are necessary. Yet two facts guarantee that even in such cases acceptable solutions can be found:

- The graduates are very variable as regards their future employment. They complete a broad basic and specialized training, and in the course of their specialized training they will have gained some experience enabling them to apply their basic knowledge in practice. This means that they will also be able to apply their knowledge if the concrete demands arising in the practice of their profession should differ to some extent from the specialized knowledge acquired during their studies.
The planning of the employment of graduates through early guidance and job interviews for each individual student creates good preconditions for their future studies. The students and the employees of the enterprise know one another, so the future graduates can prepare well for their future scientific tasks. All this is not considered merely from the economic aspect, i.e. simply to provide enterprises and institutes with qualified workers, or the provision of a higher education exclusively oriented to the future professional activity. Rather, education and educational work are looked upon as fundamental preconditions for the development of the entire personality and of all the creative forces of man.

4.3 The training of academic graduate specialists

4.3.1 The training of young scientists as a requirement for the development of science and society

The progress of science and the increasingly efficient utilization of its findings for the benefit of human society are inseparably linked with a continuous supply of young specialists to the active potential of scientific workers. that is why it is considered in the GDR that the planned and long-term development of science is essentially determined by the training of capable young scientists.34

The term 'young scientist' does not denote any legally fixed status, but applies to persons having completed higher education, who are improving their qualifications with the aid of specific measures of promotion. in particular the acquisition of higher academic degrees in systematic preparation for more demanding scientific activity at an

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establishment of higher learning or other research institution, at a factory or public institution, in conformity with international usage; young scientists are those aged up to 35 years.

The training of young scientists has always been an essential component of science and higher education policy in the GDR. The guiding idea in all phases of this development was the striving to cover all requirements for young scientists from among the ranks of the students and graduates of the country's universities and similar institutions. This was not easy, above all during the first years of construction of an anti-fascist democratic system after the Second World War. The brain-drain of other countries is in contradiction to the principles of socialist policy. The break with the bourgeois educational privileges in the present GDR, after the defeat of German fascism in 1945, laid the main foundations for the development of a new intelligentsia composed of gifted progressive people of all social classes.

As a result of great efforts, it has been possible, during the 40 years since the foundation of the GDR, to train generations of young scientists who have a high standard of scientific education, and who were brought up in a spirit of peace and socialism.

The further development of an advanced socialist society in the GDR and the speed of scientific progress has raised new demands in the training of young scientists, both now and for the coming decades. They above all result from the growing importance of science in regard to the profound changes in the political, economic, social and intellectual spheres which characterize the nature of the further development of socialist society.35

The contribution that GDR scientists are called upon to make to the safeguarding of peace and the solution of other global problems of mankind has a variety of consequences concerning the scientific qualification and personality development of young scientists. The same applies in regard to the extension of economic, scientific and technical co-operation within the framework of the CMEA and the relations with capitalist States and developing countries.

The increasingly close connection between science and production entails making new demands in the development of young scientists. This, among other things, leads to the extension of the field of opera-

tion of scientific specialists. Now, as before, an important aim of the training of young scientific workers consists in the provision of specialists for research and learning at top-level educational and research institutions. In addition, however, highly skilled scientific specialists will in future be needed to a growing extent in the different areas of social life. In the coming decades, more engineers, natural science specialists, economists and other experts, with qualifications surpassing the limits of a completed higher education, will be needed by the research and development departments of the nationally-owned enterprises and combines.

The universities and similar institutions—the main centres of training for young scientific workers—thus not only continue to be responsible for the reproduction of their own staff of specialists, but also assume competence for the increasing supply of scientific specialists for the national economy as a whole. On the other side, the responsibility of society as a whole is also assuming a growing importance in the development of the potential of scientific specialists. Co-operation between universities, academies and enterprises also extends to the selection and recruitment, the training and education, and the effective employment of higher graduate specialists.

In the GDR, considerable experience has been gained over many years as regards the co-operation between higher education institutes, academies, and institutions of practical public life. The present extension and consolidation of those relations on the basis of binding agreements has introduced a new level of quality in research co-operation, which is also marked by new demands and opportunities for co-operation in the field of training of young scientific workers. The application of joint research strategies is based on the interest of both partners in training the required number of skilled research specialists and their effective employment. Universities and combines jointly endeavour to utilize the closer interlacement of university research and the reproduction process at the combines for a systematic and far-sighted co-operation in the provision of the necessary skilled scientific specialists for the research and development at the combines and at the institutions of higher learning.

This is reflected in various ways in the agreements concluded between higher education institutions and combines, such as the delegation of combine staff members to post-graduate courses or to work as assistants (see p. 112), or the deployment of higher education staff to a combine. In addition there is the long-term or constant transition of
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scientific workers from higher education to enterprises where they will be in charge of research projects. Vice versa, experienced specialists from enterprises are recruited to the teaching staff of universities or similar institutions. In several agreements, there are stipulations concerning the development and extension of joint research teams of university and industrial research workers. Thus, for example, a joint development department for semi-conductor construction parts of the Humboldt University and the Works for Television Electronics has been functioning for several years, headed by a professor of the electronics section of the Humboldt University, who is also working as a lecturer there.

Apart from the immediate scientific, technological and economic advantages for the enterprise, the value of this co-operation, from the point of view of the university teacher, also lies in the close proximity of their teaching activity. Young scientists of the electronics, physics and chemistry sections of the Humboldt University are firmly integrated with the corresponding department of the enterprise concerned. This kind of work is of great educational value to the former, since it enables them to experience directly and to participate in the entire process, from the stages of reconnaissance and basic research up to the practical application of new scientific knowledge. From the aspect of the training of young scientists, the exchange of specialists between higher education institutes and production enterprises has a specific significance, in that it is part of the qualification and personality development of young scientists.

The following example shows the multiple advantages of co-operation between higher education and industrial production and the wide variety of forms in which this is taking place. The Otto von Guericke Technical University in Magdeburg has for many years entertained extensive relations with various combines and enterprises of different industrial branches. One of its partners is the combine Getriebe und Kupplungen. For a long time professors of the technical university have been members of the scientific advisory council of this combine, and leading staff members of the combine have been on the

teaching staff and the advisory bodies of the university. The close co-operation between the university and the combine made it possible to achieve results of a high scientific and technological standard in various fields of engineering.

The links between the combine and the university comprise the temporary exchange of staff, which can be very stimulating to both sides. In the course of such an exchange of specialists, approximately ten years ago, a young senior assistant of the university's department for calculating technology moved to the cog-wheel works in Pritzwalk. He completed that work five years later as winner of a National Prize and then returned to the technical university, where he is at present working as a lecturer. Pritzwalk offered the young scientist an opportunity to elaborate something completely new, of economic importance, not only in theory, but also in its practical application, a CAD/CAM solution entirely new for that time. Back at the university he continued to work in this field, developing possibilities of application for enterprises with an entirely different profile, arriving at the development of a second and third generation of his rationalization system of an entirely new standard of quality as compared with his first variant.37

These are just some examples out of many. The co-operation between universities, academies and enterprises is decisively determined and marked by these and other forms of work in the field of developing specialists. The training of young scientists will in the coming period take place in the context of a complicated situation. In view of the present *age structure*, it is necessary to guarantee the substitution of a large part of the most important scientific workers within a comparatively short time. A considerable number of the professors and lecturers at the universities and similar institutions will be retiring within the coming ten to fifteen years.

At the universities and similar institutions governed by the Ministry of Higher and Technical Education approximately 1,000 chairs and 2,000 lectureships will become vacant during the years from 1991-1995. Great efforts will have to be made in order to train adequate numbers of highly qualified young scientists for these vacancies.38 At the same time this situation offers very good chances to

\[37 \text{Die 'Halbkugeln' des Maschinenbaus (The 'Hemisphere' of Engineering), in: Neues Deutschland (Berlin) 12/13 July 1986, p. 9.} \]
talented and dedicated young scientists as regards their professional prospects.

Many new demands on the training of young scientists also arise from the extremely fast rate of scientific advance. Thus the trend towards integration and specialization in science imposes the need to attain higher standards of quality in the relationship between disciplinary and interdisciplinary education. This is a decisive prerequisite for a greater professional mobility of young scientists, a requirement arising not only from the rapidity of changes in science and technology, but which is also in conformity with the concept of socialist personality development.

The characteristic demands, standards and conditions objectively call for the increase of the volume, level and speed of development in the training of young scientists. That will be the main direction of work in this field during the coming years. In this connection it is essential that all aspects of this task should be considered and tackled as one.

The number of higher graduate specialists is to be increased. There will also be a growing contingent of admissions to the various establishments of training during the coming years. The standard of qualifications of the scientific teaching staff in higher education is to be further improved. There will be an increasing proportion of staff members with higher academic degrees. This is urgently needed, on the one hand in order to accomplish the reproduction of that group of scientific personnel at a higher level, and on the other hand with a view to creating the conditions for allowing a considerable part of the necessary lecturers and professors to be appointed from among the staff of scientific specialists.

At the same time it is important that the orientation in the reproduction of teachers in higher education should not be confined to the young graduates of universities and similar institutions. It is essential, above all for the sake of a further rise in the level of practical orientation in the training of students, to recruit more highly qualified scientists, with extensive practical experience of work in industrial and other institutions, as teachers in higher education. Outstanding young scientists of the academies of sciences also constitute a valuable source of

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teachers for higher education.

The augmentation of the numbers of young scientists is conditioned by the fact that more scientists with higher academic degrees are not only required by university institutions and academies of sciences, but also combines and industrial and economic enterprises require larger numbers of highly qualified scientific specialists.

The level of the education and training of young scientists must constantly be improved. The proven principle of the unity of a solid foundation of scientific specialization, ideological and political education and valuable moral and ethical qualities, is being applied now as before. Moreover, the orientation is to combine specialization in one field with the augmentation of the profile of scientific training and education. The importance of fundamental theoretical and methodological knowledge is increasing in the face of the speed of development in science. A broad and solid foundation of knowledge is an essential prerequisite for greater professional mobility of young scientists and their continuous further qualification. It is also endeavoured to attain a greater differentiation in the training of young scientists on the basis of a generally high standard of their education, paying greater attention to the relationship between the respective fields of employment and activity and individual potentials, talents and interests. In this connection the specific advancement of highly talented young scientists within the scope of their training assumes particular importance in view of a systematic development of top-class scientific specialists.

Elevation of standards also comprises the development of modes of behaviour and value orientations among young scientists, which are indispensable for successful scientific work. These include qualities such as readiness and ability to face demanding scientific work, to take over responsibility and risks, to show courage in penetrating unexplored ground in research, persistence and endurance, willingness and the ability to participate in exchanges of scientific ideas and co-operation.

The speed of development in the training of young scientists urgently needs to be accelerated, as the present situation is unsatisfactory. That is why an important task in the near future will be to make sure that graduation procedures are completed according to schedule, that the number of doctorates discontinued or not completed successfully, or completed with delay, should be considerably reduced and the intervals in time between the acquisition of the different academic
degrees should be shortened. In this way a larger number of scientists should acquire higher academic degrees at a young age, creating the conditions for the appointment of young scientists as lecturers and professors and other leading positions in scientific work. The acceleration of the speed of qualification, however, should on no account reduce the standard of quality.

4.3.2 Academic degrees—landmarks in the development of young scientific specialists

Higher academic degrees have proved to be important instruments in the training of scientific specialists all over the world. In the GDR, three academic degrees are conferred:

- Diplomas in a branch of science (Dipl.): e.g., Diploma of Chemistry, Diploma of Engineering, Diploma of Medical Science, Diploma of Philosophy.

- Doctorate of Science (Dr.): e.g., Dr., Rer. Nat., Dr. Eng., Dr. Med., Dr. Ec., Dr. Phil., Dr. Ped.

- Doctor of Sciences (Dr. sc.): e.g., Dr. sc. Nat., Dr. sc. Techn., Dr. sc. Med., Dr. sc. Phil., Dr. sc. Ag.

The terms Dipl., Dr., and Dr. sc. are used to denote the academic degrees. The corresponding finals for the doctorates are the A-doctorate (Dr.) and the B-doctorate (Dr.sc.). The academic degree of Dr. sc. replaces the previous title of Dr. habil. (habilitatus). Some scientists, who acquired their Dr. habil. before 1969, kept the old title, others had it changed to Dr. sc.

As can be seen from Table 30, the number of completed doctorates has continuously increased. During the Five-Year-Plan period, from 1981-1985, an annual average of approximately 3,980 A-doctorates and 750 B-doctorates were awarded.

Ibid., p. 148.
Comparing the number of completed A-doctorates with the figures for higher education graduates four years previously, it will be seen that the present graduate doctorate quota is 19 per cent (see Table 31). This quota has continuously increased in recent years. At the same time it should be noted that there are considerable divergences between the different branches of science.

The acquisition of these two types of doctorate degrees plays a specific role in the systematic training of young scientists, although of course they are not the only ones to acquire higher academic degrees. On the other hand, the training of young scientists is not confined to the acquisition of a doctorate degree; it also comprises other aspects of qualification in scientific subjects, in the fields of politics and educational science, experience in research, science management, international co-operation, and many other areas.

The obtention of academic degrees in the GDR is governed by standard regulations. The principles underlying the award of academic degrees are based on the assumption that such degrees are socially necessary grades of qualification. This implies that the acquisition of such degrees is regarded as an objective social requirement, and an acknowledgement of the fact that the candidate concerned is making a
Table 31: Graduate-doctorate quotas in branches of sciences - Completed A-doctorate in proportion to higher education graduates four years previously (in per cent)

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<tr>
<td>1985</td>
<td>19.9</td>
<td>53.1</td>
<td>14.4</td>
<td>63.1</td>
<td>26.3</td>
<td>7.7</td>
<td>16.3</td>
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<tr>
<td>1984</td>
<td>18.7</td>
<td>48.8</td>
<td>14.3</td>
<td>58.3</td>
<td>27.2</td>
<td>7.9</td>
<td>20.1</td>
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<tr>
<td>1983</td>
<td>16.6</td>
<td>42.5</td>
<td>10.9</td>
<td>60.6</td>
<td>16.6</td>
<td>10.5</td>
<td>16.5</td>
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<tr>
<td>1982</td>
<td>12.2</td>
<td>36.3</td>
<td>7.1</td>
<td>53.1</td>
<td>16.9</td>
<td>5.4</td>
<td>12.6</td>
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<tr>
<td>1981</td>
<td>12.2</td>
<td>35.7</td>
<td>7.1</td>
<td>(x)</td>
<td>14.4</td>
<td>4.7</td>
<td>14.3</td>
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<td>1980</td>
<td>10.2</td>
<td>27.4</td>
<td>5.5</td>
<td>53.6</td>
<td>14.1</td>
<td>4.1</td>
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(x) No valid figures obtainable due to restructuring of medical studies in 1977.

Source: Ibid. pp.31-34, calculation on the basis of tables 15 and 17 therein.
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contribution to the advance of science and therefore of the socialist society. A condition for the award of the highest academic degree—that of a doctor of science—is, for example, that the candidates produce research results which set standards, or help to set standards in science; they must candidates must give evidence of successful work as heads of scientific research teams.

Of course the concrete requirements concerning the acquisition of academic degrees changes with time. Thus, the relevant regulation in 1968 was amended in 1982, to the effect that academic degrees can also be awarded for outstanding inventions. The award of an academic degree however is always associated with an independent original achievement in science. In this sense, therefore, the acquisition of academic degrees not only serves the qualification of scientific workers, the diploma and doctorate theses at the same time constitute a rich fund of research achievements.

The links between qualification and research are one of the main instruments for further improving the process of completing doctorates. The integration of graduation theses within the research projects is a method of striving to ensure that problems of particular importance for science and society should be dealt with in diploma theses and dissertations. This is of great significance in regard to the utilization of the results obtained through research. All experiences show that this is also of great educational value in the training and education of young scientists. Awareness of the usefulness for the society is an important factor in motivating strenuous scientific work.

The scientific councils of universities and similar institutions and corresponding bodies of other scientific research institutions are authorized by the Minister of Higher and Technical Education to award academic degrees. The scientific councils and the commissions appointed by them assess the examination results of the graduation candidates and decide whether they comply with the respective demands. They base their judgement on the opinions of competent scientific specialists. A- and B-doctorates involve a public defence of the thesis submitted, at which the candidates are required to give evidence of their ability to substantiate the practical and theoretical significance of their research results.

Acquisition of a diploma and the successful completion of the main finals are the prerequisites for the award of the academic degree of a doctor of some branch of science (Dr.). The degree of a doctor of
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... (Dr. sc.) as a rule presumes the previous acquisition of the degree of 'Dr'.

4.3.3 Forms and ways of training higher graduate specialists

The characteristic objectives and demands in content in regard to academic degrees basically apply to all forms and ways of training higher graduate specialists.

At present the three main ways to undertake this kind of training are: research studies; scientific post-graduate courses; and scientific assistant lectureships.

But there are transitory and additional forms. A considerable number of candidates acquire higher academic degrees, above all that of 'Dr.', as extra-mural post-graduates, i.e. not through the aforementioned institutional forms.

The three main ways complement one another and partly merge with one another. Thus, many assistant lecturers are offered the opportunity to complete the last part of their dissertation within the scope of a partial post-graduate course, after a few years of work in learning and research.

Whereas research studies exclusively serve the purpose of training young scientists for the acquisition of a Dr. sc., post-graduate studies lead to the acquisition of both the degrees of 'Dr.' and 'Dr. sc.', as is the case also as regards assistant lectureships.

The various forms of training higher graduate specialists have a different historic development. The oldest form is that of the assistant lectureship, which already existed in higher education in capitalist Germany and was continued after 1945. Post-graduate studies have existed in the GDR since 1951. They were introduced at a time when a larger number of young scientists needed to be trained within the scope of the socialist transformation of higher education. The most recent form of training young scientists was introduced in 1968, namely research studies.

(i) Research studies: this is a form of training young scientists for work in learning and research at scientific research institutions. Furthermore, research students may be trained for work in research, development, technological preparation of production processes and control at combines, enterprises, co-operatives and institutions in other areas of public life. Through research studies, students with particularly
outstanding scientific ability and proven in their socialist activities are given an opportunity to acquire their academic doctorate (Dr.) immediately after the completion of their higher education. Thus, particularly gifted and suitable young specialists have the possibility of preparing for their second academic degree after the acquisition of their first degree—the Diploma—without loss of time. A course of research studies extends over three years; in certain cases that period may be further extended up to one more year. It is concluded with the award of a 'Dr.' degree (doctor of a branch of science), provided of course that the requirements laid down within the relevant regulations have been fulfilled.

The timely selection and long-term preparation of suitable students is an essential prerequisite for the successful outcome of research studies. As a rule the selection begins during the second or third year of studies. It has increasingly proved to be useful to train future research students according to special programmes and to give them particular promotion during the time of their initial higher education. The preparation for research studies above all includes the concentrated involvement of these selected students in research projects, enabling them from an early stage to accomplish independent scientific work, and teaching them the methodology of scientific work. Other measures consist in obliging future research students to attend specific lectures, to accomplish tasks surpassing the scope of the standard plan of studies, and giving them opportunities to sit for their examinations and acquire their Diploma before schedule. Due to such measures, future research students may complete their higher education as early as a year before the end of the regular envisaged period and immediately take up their research studies.

The content of research studies is determined by the fulfilment of the demands made in connection with the award of the ‘Dr.’ degree. Work is focused on research in a specific field of science, the results finding expression in a dissertation or an equivalent achievement. The research students extend and consolidate their theoretical and methodological basic and specialized knowledge, as well as their Marxist-Leninist education and knowledge of foreign languages. Research students are obliged to lecture two hours a week, and as a rule their teaching activity takes place in the form of seminars and exercises with students; this gives them their first practical experience in the field of training and education. Research students who have not acquired their Diploma do so in the first year of their research studies.
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Each research student is individually supervised by a lecturer or professor, working according to an individual plan of work jointly drawn up by the student and the tutor, under the constant control of the latter. Research students are members of the university as trainees; their future employment must be determined prior to or on admission to the course.

Research students are paid a basic grant of 500 Marks a month. Additional grants are awarded on the basis of achievements. They are granted further financial assistance according to their social situation: children's allowances, marriage allowances, money for books, travel, refund of fees for educational courses or lectures, payment of the costs of the required number of copies of their dissertations, etc. Research students are covered by the social insurance and benefit from additional accident insurance.

In 1984, the number of research students was approximately 2,600, and this figure has increased each year. At present the annual new admissions total more than 800. Up to the year 1990 they are envisaged to increase further to 1,200. Approximately 20 per cent of all research students are natural scientists; 27 per cent are specializing in technology; 11 per cent are agronomists, and over 40 per cent are social scientists.

(ii) Post-graduate studies: this leads to higher academic degrees, above all for scientific workers with practical experience, and are particularly suitable for those already employed in leading positions as scientific specialists or envisaged for taking over such work. Part of the post-graduates are employed in institutions after the completion of their course of qualification. The specific feature of post-graduate studies—as distinct from research studies—is that as a rule admission requires evidence of several years of successful work in practice. This means that post-graduates starting their advanced further qualification courses already have practical professional experience, and on completion of their doctorate they will generally be a few years older than graduates of research studies. There are two basic forms of post-graduate studies:

- Planned post-graduate courses extend over three years and take place with complete exemption from professional work. During a course of planned post-graduate studies the candidates can fully concentrate on their dissertations and the other requirements for the acquisition of a doctoral degree. They are integrated into the work teams of
their respective institutions of higher education, they are assigned to one of the tutors and work according to an individual programme. Their place of employment is legally obliged to re-employ them after the conclusion of their course of studies. At the same time these postgraduates are members of their respective university or institution for the duration of their course. They are obliged to teach in their specific subject for two hours a week.

Admission to planned post-graduate studies takes place by way of delegation by the State and scientific institutions, enterprises or other places of employment of the candidate in question, or on the basis of a personal application by the latter. The question of admission is decided by the head of the respective establishment of higher education, or of the centre of qualification concerned.

These post-graduates receive a grant to the amount of 80 per cent of their average monthly net remuneration during the last 12 months prior to starting their post-graduate studies. As in the case of research students, they are also covered by the valid financial regulations as regards additional grants for outstanding results, additional benefits for books, travel expenses, examination expenditures, social and accident insurance, etc.

Special forms of planned post-graduate studies include part-time post-graduate courses, special courses for women post-graduates and post-graduate studies abroad.

- Unplanned post-graduate studies extend over four years, without interruption of professional work. The scientific work within the scope of post-graduate studies is as a rule closely linked with professional work. Post-graduates of this category receive assistance to help them comply with the demands for preparation of their doctorate. In addition to their annual holidays they are granted 70 days free of work (up to 100 days for women). Post-graduates of this category are not members of their respective institutions of higher education, but they are assigned to a tutor and given the opportunity to augment their scientific profile by taking part in the scientific programme of studies at the institute. Post-graduates of this group are always delegated. Correspondence courses at universities or similar institutions abroad represent a special form of unplanned post-graduate studies.

The number of planned post-graduates (including those in special courses) was approximately 1,500 in 1984; the number of unplanned post-graduates was 2,800. After a period of temporary stagnation, there
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has been an upsurge in the admission of post-graduates since the end of the seventies, without, however, exhausting the capacities of this means of further qualification. Higher education policy is at present oriented towards a clear increase during the coming years of the present parameters, with about 600 new admissions of planned post-graduates and slightly more than 700 new admissions to unplanned post-graduate studies.

Above all, in view of the growing requirements for lecturers and professors, increased efforts have been made during recent years to extend the capacities also for post-graduate studies in preparation for acquiring the academic degree of a doctor of sciences. Whereas this way of qualification had still been the rare exception during the seventies, the number of post-graduates preparing for their 'Dr. sc.' has considerably increased since that time.

(iii) Assistant lecturer: this represents a post of employment at a scientific institute of higher education, and at the same time a way of developing higher graduate specialists. Scientific assistants are employed as members of the staff of universities and similar institutions in all main areas of work, training, education, research, further education, science management, and at medical institutions as doctors.

High demands are made on scientific assistants, as on all other groups of the staff of higher education establishments, who require solid foundations of scientific, political, educational and organizational knowledge and abilities. The systematic qualification and further education therefore forms part of the obligations of every assistant. For part of these assistants it is an essential aspect of their qualification to acquire the academic degree of a ‘Dr.’ and a ‘Dr. sc.’. There are two groups of assistants:

- Assistants with temporary work contracts: these are young scientists employed for a period of four years at an institution of higher education. During that period, assistants, under the guidance of lecturers and professors, conduct seminars and exercises with students, give guidance in practical courses and accomplish other tasks of teaching and guidance in initial and further training, in research projects and science organization.

At present, and for the near future, young graduates of higher education without any doctoral degrees are as a rule employed as assistants for limited periods of time. The acquisition of the ‘Dr.’ degree is the main objective for the great majority of assistants with temporary
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work contracts. A year before the expiry of the contract a decision must be made as to the further employment of the young scientist. Some of the assistants will remain at the institution as permanent staff members, others pass on to academies of science and other centres of research, and a certain number will go on to work in industrial and other enterprises. The successful conclusion of the A-doctorate is an important criterion in the decisions concerning further prospects.

For several years intensified efforts have been undertaken to give more systematic promotion to assistants with temporary contracts in their endeavours to improve their scientific qualifications. Qualification agreements are concluded with assistants taken on without a doctoral degree, with the aim of preparing for its acquisition. Growing numbers of assistants with temporary contracts are being taken over as part-time post-graduates during the last phase of their employment at the higher education institute in question. This may last from six months to a year. During that time the candidates can fully concentrate on completing their dissertations, having been relieved of other tasks.

The significance of temporary assistant posts lies in the guarantee of the planned fluctuation of part of the scientific staff, systematically directing higher graduate scientists towards institutions of social practice, facilitating the qualification of consecutive generations of young scientists at the institutions of higher education in line with their functions, without the need of constantly increasing the number of planned vacancies. Temporary employment as assistants offers young people an opportunity to find out whether they are suited for permanent professional work in higher education, or whether their real potentials are situated in other fields. As a whole, the employment of young scientists as temporary assistants in higher education is intended as a means to promote the mobility of young scientists.

- **Assistants in permanent employment**: these are scientific workers employed as permanent staff members of an institution of higher education. The difference from the temporary assistants consists in the greater maturity and experience in scientific work, practical professional activity, and a more advanced qualification. Today, in principle, only persons with the Dr. degree are employed in higher education establishments of the GDR as permanent assistants. At present the proportion of permanent assistants with the first doctoral degree is 70 per cent. The further elevation of the level of qualification of assistants is one of the most important tasks for the coming period. The aim is for a
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greater number, above all of younger assistants, to go beyond the first doctoral degree to the acquisition of the highest academic degree of a 'Dr. sc.'.

Compared with the research and post-graduate students, assistants represent the largest group of young scientists, taking into account that not all assistants can be considered as young scientists. At the institutions of higher education governed by the Ministry of Higher and Technical Education alone, approximately 6,700 temporary and 7,800 permanent assistants are at present employed.

Regardless of which form of training of higher grade scientists is adopted, it is always considered that, in principle, it is in every case a matter of first-ranking importance for the progress of science and technology, culture and education, health preservation and all other areas of social life. The qualification and further training of young academic specialists is a profoundly humanist mission in compliance with the requirements and interests of society as well as with those of the individual development of young people.

In the training of young specialists, we above all rely on the experiences of our scientists. Successful university teachers attribute particular importance to the development of a political and intellectual climate in the teams under their guidance, in which the striving for good results, a sense of responsibility and critical evaluation are promoted. False considerateness and glossing over shortcomings lead to mediocrity and ultimately to losses for science and the economy.40

Finally it should be pointed out that, in 1979, the GDR signed the Convention on the Recognition of Studies, Diplomas and Degrees of Higher Education in the States of the European Region. This Convention was created at the initiative of UNESCO and is part of the endeavours on the part of the Organization to attain worldwide agreements in this field. In the GDR, this Convention became valid as from 19 February, 1982. Up to the beginning of 1985, the GDR concluded 30 bilateral agreements on this basis with 29 States on the mutual recognition of testimonials, academic degrees, studies and duration of studies. The conclusion of such agreements represents an important

aspect of the GDR's international scientific and academic relations.  

4.4 Post-graduate training for specialists in research and development

Apart from the ways of higher training for scientific specialists described above, there is a wide range of opportunities for post-graduate training, which are necessary in order to keep up with the rapid development in science and technology. Post-graduate training here comprises all educational programmes subsequent to university graduation or the completion of technical college by engineers and economists which can serve to consolidate, extend and update their professional skill and knowledge. Post-graduate training is directed towards the improvement of qualifications within an achieved branch. Participation is confirmed, or testimonials are issued, part of them awarding the titles of degrees or additional professional definitions. In this section, the system of post-graduate training will be presented, with particular reference to the educational facilities for those already employed in research and development.

The constitutional principle that a continuous socialist education, training and further qualification must be guaranteed to every GDR citizen applies to scientific specialists as to all other members of our society. Accordingly the ‘Law on the integrated socialist education system of the GDR’ makes managers of State and economic establishments, institutions and enterprises, responsible also for the further qualification of university and technical college graduates employed within the range of their competence. The law further prescribes that the relevant necessary measures must be decided by agreement of higher education establishments, technical colleges, the Chamber of Technology and

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the scientific societies. Higher education establishments and technical colleges for their part are pledged to make scientific knowledge and experiences accessible to a wide circle of higher education and technical college graduates.

On the basis of other legal regulations participation in post-graduate specialization is supported by enterprises and institutions through exemption from work without financial loss, possibly by paying the costs of tuition and travel involved, etc. In this way, the elementary right to education for all is implemented in the specific domain of post-graduate studies.

As a result of the educational policy of the GDR, efficient systems of further vocational qualification for graduates of higher and technical education have been developed. These systems ensure that the requirements of further vocational qualification can be complied with also for specialists working in research and development. Importance is attached to the close links between the further vocational qualification of those employed in research and development with their professional activity. The organized forms of further qualification do not relieve specialists of their responsibility for independent systematic efforts to continue the constant improvement and advancement of their professional qualifications.

Organized further training is intended to supplement the process of individual professional qualification. For this purpose further education facilities should be made available which can react to necessary anticipated professional developments and changes. These are above all further specialization courses preparing for work in particular areas, and which are frequently linked with the acquisition of specific qualifications. On the other hand, the guarantee must be given that the range of courses offered can rapidly and flexibly react to qualification requirements arising with increasing speed and differentiation from the rapid development of the advance of science and technology.

In 1985, approximately 250 different post-graduate courses were conducted. These comprised between 250 and 550 hours of instruction combined with a comprehensive programme of independent studies and distributed over a period of two to four semesters. For the majority of subjects in which post-graduate studies take place, certificates of qualification are issued upon successful completion, as for example in the

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subjects: patents rights, inventions and discoveries, welding technology, automation technology, customers' service, labour safety and safety technology.

The differentiation concept of the relationship between planned measures and flexibility in vocational further qualification comply with the specific conditions in the respective professions, and ensure that possible formal trends of development may be successfully encountered. Examples to be mentioned of further qualification courses adapted to the specific conditions of particular professional categories are the further training courses for teachers at general polytechnical high schools, the system of further medical specialization, the permanent further education of medical workers, and the wide range of further qualification facilities for natural scientists, engineers and economists.

In the further qualification of higher and technical education graduates, enterprises with educational facilities, university institutions, technical colleges and various social organizations work closely together. Each of these establishments develops activities which will make the best use of the specific conditions within the respective given fields.

Factory academies and enterprises, essentially for the qualification of skilled workers and foremen, have developed into efficient educational establishments, also participating in the further qualification of higher and technical education graduates. This applies in particular in regard to qualification requirements for specific functions and tasks, directly linked with the development and application of new technologies and the production of new generations of products at the respective enterprises. Factory academies and schools are State institutions subordinate to a State authority.

As far as social organizations are concerned, the Chamber of Technology should be mentioned in the first place for its extensive activities in the field of further professional qualification of higher and technical education graduates. It is an organization of scientists, technologists and economists; it is a voluntary working community, which pursues the aim of promoting the advance of science and technology. This is linked with extensive activities in the further qualification of engineers, economists and innovators in production. The facilities offered by this organization for systematic further qualification, through its short direct or correspondence courses, are used by approximately 75,000 specialists every year. As regards the content of these courses, more than one-quarter of the total number of participants attend for
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the subjects: management, economics, invention and innovation, and data processing. Nearly one-quarter of the participants make use of qualification opportunities in energy and materials economics. About 30 per cent of the participants attend courses on technological subjects, including the application of microelectronics and automation technology. One out of five participants in direct or correspondence courses chose foreign languages, health preservation, labour safety and fire precaution as fields of qualification. It is expected that, in the future, qualification courses in the fields of microelectronics, calculating technologies, automatic construction and production preparation (CAD/CAM), flexible automatic production systems, new processing technologies, new materials and biotechnology, will gain in significance.44

The different scientific societies are making an important contribution to the further professional qualification of graduates of higher and technical education. These societies are associations of scientists and innovators, teachers, doctors, technologists and other scientific workers, associated with central and other administrations, academies, or the Chamber of Technology. The approximately 110 scientific societies at present operating in the GDR offer an opportunity to scientific specialists in the natural sciences, in medicine, technological, agricultural and other disciplines to associate in specialized professional organizations. The general purpose is to promote the development of the respective branches of science, to consolidate the links between scientific research and social practice, and to promulgate the dissemination and application of research results. To this end, these societies promote the exchange of scientific experiences at a national and international level, organize scientific conferences, colloquia and qualification courses; they issue their own publications and have an influence on instruction and teaching in their respective fields. The specific function of these societies in regard to qualification is above all determined by their disciplinary orientation, which also substantiates the particular significance for the further scientific qualification of research workers. Thus, the twelve societies of natural and social sciences attached to the Academy of Sciences of the GDR unite specialists of such fields as biology, chem-

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istry, mathematics, physics, informatics, geology, history, cosmic research and space navigation. The functions of the societies attached to the Academy of Sciences of the GDR are attended by some 41,000 participants a year.45

The establishments of higher education and technical colleges occupy a specific and important place among the institutions running post-graduate training courses. For 1985, they offered a total of approximately 600 courses for the qualification of engineers, economists and natural scientists, and 100 post-graduate training places.46 In higher education institutions, post-graduate training is increasingly becoming a domain of activity of equivalent importance with learning and research. The following comparison will indicate the extent to which this activity is already influencing the structure of work of higher education institutions: in 1984 there were approximately 110,000 full-time students to about 60,000 university and technical college graduates participating in post-graduate courses.47 As in previous years, the number of participants in higher education courses of post-graduate studies also increased in 1985, attaining the highest number hitherto of about 74,000 university and technical college graduates.48

The development of the above-mentioned activities in the field of post-graduate further qualification is determined by the decision on the 'Tasks of universities and similar institutions in the developed socialist society',49 which outlined the targets of the Socialist Unity Party in its


higher education policy for the eighties. It was emphasized that in view of the increasing numbers of university and technical college graduates in the national economy and the need to increase the efficiency of scientific specialists in practical life, the systematic further qualification of these graduates has become an extremely important part of the work of higher education establishments. The offers of post-graduate training opportunities must be further extended and differentiated in compliance with the specific possibilities of higher education institutions and with the requirements of the national economy. Further courses and seminars must be arranged in close co-operation with enterprises, combines and the scientific societies and be utilized more efficiently for the introduction of the latest results of research in different fields. Particular attention should be paid to the work and the extension of further education centres for essential areas of national economic importance.

The institutions of higher education, in order to implement the tasks set, have built up a wide variety of different facilities for further qualification. These range from courses of further qualification extending over two to four semesters, to differentiated forms of studies, such as intensive courses, training courses, problem-solving seminars, extending in duration from a few days to several weeks, and to scientific conferences and congresses.

University institutions, as centres of learning and research dispose of specific capacities for the deployment of activities in post-graduate studies. They above all rely on the potential of scientific staff, comprising the qualities of teachers and research specialists in their work of teaching and research. The disciplinary multiplicity, interdisciplinary complexity and thematic variety in basic and applied research are particularly important aspects of the unique profile of the work of further qualification. Also, post-graduate further qualification in higher education is marked by the links with other research centres at a national and international level and the wide network of relations with different fields of social practice. On this basis the institutions of higher education are making their specific contribution to the further professional qualification of university and technical college graduates.

The proximity of educational content to the professional work of the course participants and their orientation towards complex problems and tasks of practical significance, which is an important aspect in all fields of further qualification, frequently imposes the need for the co-operation of representatives of several fields of science, which helps
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to overcome disciplinary limitations. Vice versa, the effectiveness of further education at university institutions is enhanced in particular if the latter resort to scientific knowledge resulting from or following up interdisciplinary research work. The close link between further education and research is above all essential so that university institutions can comply with their responsibility for ensuring the necessary preliminary educational work among specialists employed in industry. This applies in the first place in regard to further education for imparting the latest theoretical knowledge obtained in the field of basic research. This largely exerts an initiating influence as regards new developments, which specialists working in industry could be encouraged to pursue. In this way further education can make an important contribution to the acceleration of scientific progress, from basic research to development and the industrial evaluation of scientific knowledge.

One form of further education, with a specific research orientation and concept designed for those employed in research and development, is conducted at special further education centres of university institutions. These centres, which admit top-class specialists, constitute a form of further training primarily for fields which occupy a key position in the acceleration of scientific and technological advance. They are headed by a leading scientist in the respective field, assisted by a council of experts. Concepts for the development of these courses are considered and the content planned and co-ordinated with other partners.

Of particular importance at these centres are the problem-solving seminars. Scientists of the respective branches from higher education institutions, academies and industry are brought together at such functions with the aim of considering ways of finding solutions to problems of research and practical application of research findings. Another purpose of the work of the centres consists in making the conclusions drawn at these seminars accessible to the widest possible audience of potential users.

Further education centres of this kind at present exist for the following branches: microelectronics, energy generation and supply, energy technology, mathematical cybernetics and computer technology, information processing, polymer materials and solid-state mechanics, construction and rational use of material.

With the creation of centres of scientific concentration in higher education for fields of first-ranking economic importance, such as CAD/CAM and biotechnology, considerable possibilities for further
education were provided at the same time, which are characterized, like the projects conducted at the special further qualification centres, by their specific research orientation.

This category also includes the 'Technika' at university institutions (see chapter 2, section 2.2). As a rule, set up, developed and used jointly with industrial enterprises, they dispose of the most up-to-date and highly efficient research technology. These institutions are a kind of combined research, measuring, control and experimentation centres, scientific workshops, training and further qualification laboratories, with the main educational concentration on further qualification.

In describing the different opportunities open to research and development specialists for acquiring new information and knowledge for their professional work, we should also mention the centres of consultation and advice functioning at higher education institutions, of which there are more than 200. They are important mediators between higher education and practice, they promote the prompt transfer of research results to industry, and they are centres for exchange of experiences on problems of science and technology.

Finally, the extensive activities of higher education institutions in the organization of scientific conferences and congresses should not be forgotten. An increasingly wide circle of scientific specialists from industry take part in these conferences, which gives new impetus to the transfer of science to practice.

At the XIth Party Congress of the Socialist Unity Party, as pointed out before, the basic orientation towards an effective unification of the scientific potentials of higher education and academy institutes with industrial combines was reaffirmed. Undoubtedly this poses new and growing tasks for post-graduate training and education. At the same time, this fusion creates advantageous conditions for co-operation in the expansion of the range of types of further qualification offered. This also applies in regard to deducing further qualification requirements from joint research strategies, the effective application of further qualification in the transfer of research results and their rapid and widest utilization, and in regard to making the best use of facilities available to both partners for ensuring the material technology and personnel for further qualification projects.

A satisfactory standard could be reached also in the sector of education because of the close co-operation of all institutions and organizations involved in the work of further professional qualification.
This basis and the conditions and possibilities for further development offered by the society guarantees that further education will be able to comply in future with the demands on its function in the qualitative reproduction of the considerable intellectual potential available in the GDR.

This intellectual potential is also dependent on the ability profiles, conditions of development and biographies of the individual youth. To identify the degree and nature of this dependence, the following section gives the results of a survey undertaken in the field of mathematics; this field was chosen because of its immense importance for the development of science and technology.

4.5 Preparation of young people in mathematics

In chapters 3 to 5, several forms of special preparation of young people for scientific work have been systematically described. The following report on research results in the work of psychologists shows, for a cross-section of time, the promotion of young people in mathematics. The authors of this investigation pursued the task of developing reliable methods of diagnosis for the early selection of particularly capable children and young people. The presentation also contains a number of assessments of the present effectiveness of specific measures of promotion, which makes the study particularly interesting.

Since the seventies, in addition to the special music, sports, and foreign language schools already in existence, special classes and schools for mathematics/physics and technology have been introduced in all districts of the GDR. (A district is a regional unit, of which there are fourteen in the GDR, apart from the capital.) These establishments aim at educating socialist personalities to have a harmonious intellectual, physical and character development, in the same way as other general education schools. The specific tasks of these special schools as a form of concentrated promotion of talents, and the specific features of education in the subjects of respective concentration, at the same time influence the entire nature of education and instruction, which mark the whole style of work and life at these schools. Instruction in the general education subjects follows the same syllabus and curricula as at the other schools.
Since the specific ability of pupils is mostly not confined to the limitations of their particular interests and talents, standards will generally be higher in every respect at the special schools. It is characteristic that extra-mural activities not only concentrate on the special subjects; a many-sided school life is developed and pupils' minds are opened up to the humanistic values and ideals of socialist society in social science instruction and art-related activities. As these selected pupils are potential top-class specialists in science or economics, great importance is attributed to their moral and ideological education and the development of their social behaviour.

The selection of suitable pupils is based on the development of stable interests and specific achievements in previous forms of promotion, such as circles on technological or natural sciences subjects, optional instruction, special camps (summer schools), where recreation and interest group activities are combined, and at pupils' academies. Success in 'Olympic' contests in mathematics, physics and other subjects are of particular importance. The overall standard of achievement in the subject of specialization is an important criterion for selection. Admission to the entrance examinations, which mostly take place in oral and written form, is based on recommendations by the schools attended hitherto, by extra-mural establishments, and partly on individual applications.

An investigation, conducted by the research group for higher education psychology of the Central Institute of Higher Education in Berlin and partly in conjunction with the Central Institute for Youth Research in Leipzig, came to conclusions in regard to personality qualities and development conditions of a group of talented young mathematicians to be considered in the elaboration of a scientific concept on the nature of special talents, with a view to a more systematic adaptation of programmes of educational promotion to the individual personality structure. The investigation was conducted in three separate parts, composed of a combination of longitudinal and cross-sectional investigations of mathematically gifted young people. The target of all the investigations was to obtain the most comprehensive information concerning the ability profiles, conditions of development and biographies of the young people concerned.

Investigation 1 was conducted in a first stage during the years 1966-1967, with pupils of the first two classes of the special courses in mathematics at the Humboldt University, and completed in a second
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and third stage in 1981 and 1983, by the collection of information on the further development of the same pupils.

Investigation 2 was conducted with students of mathematics at the Humboldt University, and the first findings were followed up in 1983 by the registration of their successful graduation and subsequent professional development.

Investigation 3, conducted jointly with the Central Institute for Youth Research in Leipzig, dealt with the development and further success of former winners of 'Olympic' mathematics contests at school, university, work, and in private life. Altogether approximately 600 mathematically-gifted young people were surveyed, with the main proportion of approximately 500 test persons falling within Investigation 3.

These particularly gifted young people were found to be able to attain considerably better results than normally intelligent people of the same age, with the same effort of work and identical educational conditions. No statements were made in regard to the genesis of these differences in performance and the varying degrees of intellectual abilities. We give some of the preliminary observations concerning the intellectual abilities of these gifted young people and the utilization of that potential for obtaining a higher standard of intellectual achievement in the given educational and living conditions.

For a part of the test persons involved in the three investigations, the intelligence structure test by Amthauer was used for registering the standard of intellectual ability of the test persons—with relevance to the corresponding complementary investigations of the respective age and educational groups. Psychologically-tested personal questionnaires, partly standardized for the GDR, were used for obtaining information pertaining to non-intellectual personality qualities. Development and living conditions were recorded with the aid of open and closed questionnaires and complementary in-depth interviews.

In the following, the first results of the three investigations will be elucidated in the context of their significance for the selection and promotion of talents.

The intellectual ability of gifted young mathematicians is far greater than average for their respective age-groups, even surpassing that of students of non-mathematical faculties. A high degree of general intelligence—above the average of the corresponding age and educational group—appears to be an essential prerequisite of mathematical talent. In addition there is a specific ability, above all revealed in
coping with demands in the fields of abstract and logical thinking, rethinking and mental flexibility, i.e. creative thinking. Hitherto it was only possible to mark the direction of specific abilities with the aid of psychological methods, yet without any adequate registration of the particular features and the extent of these outstanding capacities. This can only be ascertained by further in-depth investigations.

The 'Olympic' mathematics contests at a national level, the oral and written examinations for admission to a special mathematics class offer a good basis for registration of such outstanding gifts. Success in 'Olympic' mathematics contests indicates the presence of a specific mathematical ability, but cannot be valued as more than an indicator, since individual talent must also be coupled with a stability in contests, which does not prevail in every case. Our methods of analysis for the registration of non-intellectual personality qualities revealed the image of the introverted special talents in different variations. Among the gifted young mathematicians, we found a majority (about 80 per cent of the test persons) of individuals with a quiet and reserved disposition, tending to self-observation, intense preoccupation with problems confronting them, opening up only in the presence of intimate friends and otherwise rather 'closed' in their behaviour, serious, reliable and diligent, even as far as being 'obsessed' with the effort of accomplishing set tasks, and fanatically involved in the solution of problems before them.

The combination of the above-mentioned personality qualities with a great general and specific capacity, leads, from an early age, to an intense and far above average preoccupation with social scientific problems, in particular natural scientific phenomena, making these gifted individuals different from the rest of their age-group. Yet nothing can so far be said about the genesis of development of these personality qualities.

The approximately 20 to 30 per cent equally talented, but more extrovert young mathematicians, are very well able to take charge of tasks of organization and communication apart from their intense preoccupation with mathematics. They are highly qualified for the accomplishment of social tasks, they are exceptionally suited for research work, and they are subsequently in a position to take up a leading place in research work without impairing their own research potentials.
Both types—the introverted special talents, tending to immerse themselves in their scientific work, as well as the exceptional research talents—are most suited to functioning as top-class specialists, promoting the advance of science in their fields, provided that working conditions in compliance with their specific types of character are offered to them.

At this point, the main conditions of development, characteristic of this group of gifted individuals from early childhood up to the present, should be briefly summed up:

1. Our test persons are characterized by an early interest in problems and questions of mathematics, natural science and technology. The overwhelming majority of test persons originate from a culturally and intellectually stimulating family environment, where their gifts were recognized and promoted as far as possible, and who had teachers aware of their abilities, systematic questions and evident interest, encouraging their admission to working-groups, circles, etc. in compliance with the special profile of their interests. Those circles were above all of a mathematical orientation, but working-groups of other natural scientific directions were also frequented. The preoccupation with the selected field of interest by far surpassed the range of the subject matter of school instruction and the average standard of knowledge of the respective age-group, and influenced the further shaping of the specific talent. The successful participation in various schools and ‘Olympic’ contests in mathematics or physics was generally followed by an early fixation with the field of interest in early adolescence (at the age of 12 to 14 years) and the corresponding choice of profession. Knowledge, skill and abilities required for the materialization of professional wishes were then further developed within the scope of interest and working communities.

2. After the completion of the extended high school, mostly very successfully, with particularly outstanding achievements in the natural science subjects, the area of studies was selected that most closely corresponded to the long-standing professional choice. A glance at investigations 1 and 3 reveals that about two-thirds of the former pupils of special schools and former winners of ‘Olympic’ mathematics contests surveyed, took up studies in mathematics and physics, whereas the others were preparing to become engineers of various branches; some become chemists or biologists. Altogether 91 per cent of the test persons are studying subjects with a strong emphasis on mathematics.
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The former pupils of special classes and schools stated that this was where they had learned how to study. The overwhelming majority of test persons were admitted to higher education on their first application, and their specific foundation of knowledge, their interest in the subject and their general commitment offered good prerequisites for successful completion of their studies. The test persons considered the promotion—in particular in out-of-school working-groups, etc.—to be very positive in the combination of demands on and promotion of the individually differing performance potentials. In higher education, on the other hand, test persons considered that the manifold possibilities of individually adjusted demands and promotion were not used in sufficient variety.

3. After what was judged to be a good to very good completion of studies, professional work was taken up. Most of the test persons wanted to work in scientific professions. So far about half of them have acquired their first doctoral degree. In the majority, the test persons are ambitious, committed and anxious to attain sound scientific achievements in their field of work and at the enterprises where they are employed. The specialized knowledge with which the test persons leave the universities is highly appreciated, but some enterprises show neglect in the full utilization of their capacities.

4. The results presented so far allow first conclusions in regard to the promotion of top-class specialists; as a whole the test persons were efficient specialists. Intelligence, interest, ability, motivation and qualification were developed from earliest youth, but there are still reserves for further improving the individual demands and promotion in compliance with ability profile and personality structure in the course of studies and in professional employment.

So far we have emphasized academic programmes of the institutions of education conducted with or without the direct involvement of the combines. An example of programmes organized by a combine will complete our discussions on the topic of higher education and the potential of science. This example of skill development of talented young people draws on the experience of Carl Zeiss Jena, one of the most active combines in the field of research and training in the GDR.
4.6 The systematic promotion of talented young people

The combine Carl Zeiss Jena, with its concentration of scientific work, research and development, and technology and production, has for many years conducted extensive education and instruction activities. This combine comprises a great national economic potential. Its 22 enterprises—which include two research centres, two engineering enterprises for rationalization, and one foreign trade enterprise—unite the main potentials of the fine-mechanical and optical industry of the GDR. Of all those employed, 23 per cent are graduates of higher or technical education. About 5,000 of the employees are directly involved in projects of research and development; 400 specialists of academies or university institutions are involved in the research of the combine on a contractual basis.

Since in our time quality and speed in scientific and technological work are becoming increasingly decisive in regard to raising standards and gaining time in the process of comprehensive intensification, we are giving the utmost attention to ways of applying our science and technology potential for the maximum effect, and continuously promoting its development. The investments in research and technology, objectively increasing in view of the revolution in science and technology, must be accompanied by intensification in this domain. The systematic training of top-class specialists in research, engineering and technology, marked by talent, diligence and personal engagement for our social objectives, has therefore become a decisive factor for the achievement of a high standard of performance in science and technology.

The discovery, promotion and challenge of outstanding gifts and talents has nothing in common with the bourgeois 'elite-theory'; on the contrary, it starts out from an opposite ideological position to the effect that all children should be given opportunities for the full deployment of their natural talents. The combines, which are called upon to attain

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50 This section has been prepared by W. Biermann and is based on an article published in Neues Deutschland (Berlin) 10. 1986, p. 10. The author is General Director of the combine Carl Zeiss Jena and member of the Central Committee of the Socialist Unity Party of Germany.

top-class achievements, are largely responsible for the training of top-class specialists.

The foundations for the training of such specialists lie in the wide range and multiplicity of educational facilities in the country and the sound base of general education for all. Yet even in the most favourable social conditions, outstanding research specialists cannot be developed in large numbers. Creativity is a mark of individual personality which may be developed and promoted, but not produced by education and a favourable social environment. The term ‘top-class’ should be understood to imply more than merely ‘conscientious accomplishment of tasks’, ‘diligent work’, ‘contribution of wise ideas’, etc. These things are also important qualities and attitudes, and we certainly have a great deal to do in order to assert them everywhere as standards of daily behaviour.

Top-class specialists, however, have to be able to apply their gifts, their willpower and their entire personality to the task of setting standards of demands in their work teams, creating ideals, especially for young people, and being a worthy example in their own conduct and attitudes. In our experience the political and moral influence exerted by a personality is as important as his technical expertise.

A systematic process of recognition and development of scientific and technical talents calls for an early start among school youth. At the trade schools of our combine we encounter young people for the first time in the course of their obligatory programmes of polytechnical subjects, taught in classes 7 to 10 of the general high school. That is a good opportunity to recognize and promote pupils with special talents in the natural sciences and to enable them to cope with the solution of complicated problems. The main aim consists in teaching them to find creative ways of accomplishing demanding scientific tasks within the scope of production work, the emulation of ideas and construction among pupils in the polytechnical ‘Olympic’ contests and in technology working-groups. In the course of these activities it becomes evident where specific abilities could be developed.

It is then extremely important to observe these pupils and eventually to employ them at the combine. We are at present doing this in two directions. In the first place our special school for specialization in technology and physics, the Carl Zeiss school, should be mentioned. This is an extended high school, i.e. an establishment of public education which admits pupils as from the beginning of the 9th class. The
school is directed towards educational requirements in natural sciences arising from the profile of the combine Carl Zeiss Jena. Approximately four-fifths of the pupils are sent on to courses of studies, continuing in the same direction, after passing their 'Abitur' examination on leaving the school, to be employed at the combine after graduation.

If this is to be successful, each potential top-class specialist needs to be identified at a very early stage, and then to be led further from one phase to the next. It is our principle to demand a standard of achievement in learning, practical training, and subsequently at work, which will continuously confront the persons concerned with the limits of their capacities. They can therefore never rest on their laurels if they wish to keep pace with current developments. At every success they are faced with a further and even more demanding task.

Apart from the systematic promotion of talents at the Carl Zeiss special school, we are trying yet another way. For the further improvement of vocational training, in 1983 the combine was set the task of trying to promote the systematic training of top-class technological specialists in an experimental vocational training class with 'Abitur'.

In this special training class, in which 15 to 20 apprentices are trained in fine mechanics, more ambitious demands are made than usual for the certificate of skilled specialization and the 'Abitur'. Of course the State plans of instruction have to be fully completed also in this class, despite the more concentrated special programme for the natural science subjects. We are not out to train specialists who do not have an adequate general education and knowledge in associated disciplines. The higher specialization is an extra curriculum for these apprentices.

Once again it became evident in this case that high demands in achievement can be fulfilled if the apprentices are directed towards ambitious aims of their own. Readiness to accomplish great achievements is developed at the age when professional abilities and interests take shape, lasting friendships are established, and ideals are formed. A great deal depends on the teachers, and they have their part to play in the scientific and technological revolution. As in all other respects, outdated concepts also need to be overcome. The success of teachers more than ever depends on the extent to which they manage to encourage young people to creative and independent thinking.

Motivating gifted, highly talented young people to develop the desire and the resolve to reach the top is ultimately the task of all involved in the process of education and instruction—i.e. parents,
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teachers, instructors. At the same time, we consider essential the development of a system of thoroughgoing promotion of talents in science and technology, strictly dependent on achievements, the social status, the attraction and effectiveness of which should be much the same as in competitive sports.

With the aim of the linear continuation of the systematic development of transition to higher levels of education and training, we consider that it is necessary to conclude educational promotion agreements. These allow the maintenance of contact with the students, the preparation of their practical training at the combine together with the educational and training establishments, and to make all provisions for the subsequent employment of graduates at the combine.

Even if everything runs smoothly, this last stage marks the beginning of practical trial. According to our experiences the most difficult point for the graduates is the adjustment to the high degree of the division of labour in research and production. The processes, requirements and rules associated with the division of labour need to be understood, so that graduates are able to recognize their own obligations and to build up the necessary co-operative relations.

As a rule, how well a graduate will adjust becomes evident after a year. During that period it may be seen whether he has a systematic, dedicated, and active approach to his work, and the degree of his social motivation and co-operative ability may be assessed. An experienced manager can by that time judge the results of the various phases of the work accomplished, how rationally they were obtained, how much originality they contain, and to what extent the numerous criteria of the reproduction process—material economy, energy saving, reliability, etc.—were taken into account.

This is by no means the end of the development of young scientists and technologists as top-class specialists, which should not be left to coincidence even after the first phase of adjustment of the graduate; altogether that phase will take from one to two years.

Since 1982, we have worked together with the Academy of Architecture of the GDR in an endeavour to continue the systematic further qualification of young scientific specialists. A concrete form of that co-operation may be seen in the creativity courses, to mention only one example. In these joint courses of 800 hours over 14 months, young scientific workers are systematically motivated to creative behaviour. At the same time, they are qualified technically and methodologically to raise the standard of their scientific and technological work, and
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to achieve a more advanced level in producing inventions and patents. Their fields of training are researches in the field of preliminary processes.

High technologies also require a great measure of interdisciplinary knowledge and activity. Genuinely outstanding achievements will in future only be attained by people who are capable of comprehending complex processes in their overall significance, and who are able to treat the necessary division of labour at all times from the aspect of appropriately fitting together the separate areas and parts of work into one whole.

Knowledge is only one essential aspect in this connection. We frequently come up against the situation as regards with very complicated practical problems, where it is extremely difficult to compose the necessary interdisciplinary team for the accomplishment of the task. Apart from the specialized knowledge, the political and moral qualities of those involved are of great importance: awareness of where and what for this work is to be done, and the resolve to accomplish top-class achievements for the economic consolidation of socialism.

The best environment for this personality formation in compliance with the requirements of our society are work teams of experienced young scientists, who, in an endeavour to achieve genuine top-class results, will set out on untrodden paths where they can themselves assess the political significance of the success or failure of their work. This is ultimately a matter of the human maturity of all involved, and of the directness and competence of team leaders and each individual member.
Chapter 5
Computer-aided information processing
as an example of the development of
progress in science and technology in
the GDR

5.1 GDR policy in science and technology in
computer-aided information processing

Among the achievements in science and technology of the second
half of our century, computers are unparalleled in their effects on social
developments. At present the development and application of
microelectronics—basic innovation for computers, computerization or
electronization—represents a main trend of the revolution in science
and technology and the development of the productive forces. The
essence of this new phase in the development of the productive forces
consists in the transfer of international work processes and functions of
mental work to technological means.

In the GDR, as elsewhere, the starting point is the recognition that
this transfer requires specific means of work, namely software. This
represents a new category of technological prerequisites, described in
their sum total as information technologies. Software is at the same
time an indispensable precondition of computer application as a whole.

Application of microelectronics therefore also means, above all,
development and application of information technology, since progress
in science and technology only becomes effective in productivity and
efficient by way of technology and its achieved level. Furthermore, it
largely depends on the efficiency standards of technology, how human
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labour can be saved and eased, and how it could become more productive and interesting.\textsuperscript{52}

Information technologies at present decide the level and speed of labour productivity and progress in science and technology in general, and they are therefore considered as key or high technologies. Whereas previously the steel consumption per capita of the population was considered the measure of the industrial standard of a country, today the consumption in microelectronics has come to replace this criterion. It has been recognized throughout the world that at present no limits can be foreseen for the application of microelectronics.\textsuperscript{53}

Two factors merit particular attention in this connection:

- The role of information technologies in regard to the intensification of all parts of the reproduction process—they penetrate all fields of human activity, they modify the content and nature of work and training, they raise problems of the development of human personality in a new way, they condition new forms of scientific work organization and management, etc.

- The integration of information technologies in the other key technologies for their necessary control and management; the connection between bio- and information-technologies is thus regarded as an essential mark of the beginning of a new phase of the revolution in science and technology.

The objective requirements of the development of the productive forces, together with the specific conditions of reproduction in the GDR—caused, among other things, by restrictions arising from the long-term development of the population fit for work, and from the shortage of raw materials—made it necessary to adopt a strategy of

\textsuperscript{52} Programm der Sozialistischen Einheitspartei Deutschlands (\textit{Programme of the Socialist Unity Party of Germany}), Dietz Verlag, Berlin, 1976.

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intensification of socialist national economic development. In 1966, the Council of Ministers and the leadership of the Socialist Unity Party held a joint conference, at which the basic problems of economic strategy were discussed, and measures were decided for their solution. In essence the transition to intensely expanded reproduction was decided.

There was also a disproportion between energy requirements and energy production; the development of the GDR during the past ten years shows that the removal of that disproportion without reduction of the rate of economic growth can be achieved. The energy-saving economic growth is ultimately based on the fact that less energy and more information is used per unit of industrial goods production. Information technology is proving to be a source of national economic growth, capable of reducing requirements in all other resources to a greater or lesser extent, without itself being replaceable by any alternative.

The factors briefly outlined above were and still are decisive in GDR policy in the field of informatics and information technology; in the following, the main phases of its development will be described. The results of that development are clearly shown, among other things, by the above-average high growth rates of the corresponding industries (see Table 4, chapter 1).

As a result of that policy the GDR is one of the few countries in the world which has at its disposal the necessary scientific and economic potential for the development, production and application of microelectronics. These great efforts were and remain investments for the future, they are requirements—and results—of the aspired to intelligence-intense economy, in which electrotechnics, electronics and engineering decisively determine the industrial structure. Basically the GDR starts out from the fact that modern products and production development in conformity with international market requirements today are inconceivable without the application of microelectronics and computers. Moreover, the ambitious social targets cannot be implemented without an industrial basis in line with the possibilities of the GDR in the long term. 54

The development of electronic calculating technology as a means of intensification in the GDR follows up the co-operation of mathematicians at the College of Technology in Dresden (now the Technical

54 Bericht des Zentralkomitees an den XI. Parteitag der SED, op. cit., p. 27 f.
University) with K. Zuse, who is internationally recognized as the pioneer of modern calculating technology; in 1941 he developed and constructed the first fully functioning (relais) automatic calculator in the world. As a result, in the GDR the first computers were produced as early as the first half of the fifties. During the sixties—particularly in the second half—essential national industrial capacities for the development and production of computer technologies were created (e.g. establishment of the industrial combines Robotron and Zentronik; development and production of the electronic calculator of the second generation R 300).

The decision in 1969 by the governments of the socialist countries to develop and produce electronic calculating technology jointly in the future was a decisive move. Two lines of development were decided:

- the Standard System of Electronic Calculating Technology - SSECT
- the System of Microcomputers - SMC

The merger of potentials of the socialist countries in the development and production of computer technology led to:

- The creation of a standard system through the participation of all countries providing the socialist States with a standard basis in calculating technology.

- The specialization of countries in particular items, allowing the concentration of development potentials and a more efficient production.

- The total potential of the countries involved in the development and production of calculating technology attained a dimension allowing long-term solutions of demanding problems.

- The alignment among the socialist countries in standards, development methodologies and management methods was promoted and the establishment of working co-operation between developers and producers also served to consolidate the amicable relations between the socialist countries.
Four years after this decision the first computers of the third generation were available as SSECT-Computers.

Recognition of the growing significance of automatic information processing or informatics led to the creation of hardware and software in 1969—to begin with at the Technical University in Dresden, and subsequently at other establishments of higher education. At the same time, specific training programmes in rudimentary informatics were developed and introduced in university courses for mathematicians, natural scientists, engineers and economists. These measures became part of the basic strategy of education, especially higher education, in the GDR, determined by the fact that in a country, the existence and prosperity of which mainly depend on the productivity of its inhabitants, education and training inevitably move to the front ranks of social values. The socialist industry as well is forced to rely on the initial and further training of its specialists, and therefore to be concerned about its development. This has been and still is of the utmost importance in connection with the application of information technology.

As in the development and production of hardware, there were at the same time agreements within the framework of the CMEA on the initial and further training of specialists. In this connection, training programmes for instruction in Management Information System (MIS) and/or Computer Aided Engineering (CAE) subjects were drawn up and introduced by joint teams of specialists. The term ‘MIS/CAE’ defines the conditions of the comprehensive application of calculating technology and other means of automation for automatic information processing in management and control of production, constructive and technological preparation, etc. Around the middle of the seventies the development of microelectronics began. It is the basic innovation required for the large-scale application of computers.

Recognizing that this new technology is applied and managed by human labour, comprehensive targets were set for the corresponding initial and further training and some of the relevant concepts drawn up were immediately put into practice. During the period from 1983-1986, these concepts led to differentiated programmes for public education, vocational training, and technical and higher education, and will be discussed in the following sections. In the field of higher education, complex courses of further training in ‘foundations and application of microelectronics’ were introduced towards the end of the seventies for all university teachers and scientific staff members of universities and
similar institutions. The objective of this measure was the long-term preparation and creation of potentials for a multiplication effect in the initial and further training of highly skilled specialists. This has today proved to be successful.

Furthermore, a number of centres of further training were set up at the universities and similar institutions, for example:

- microelectronics/informatics: Technical Universities of Dresden and Karl-Marx-Stadt;
- CAD/CAM: Technical Universities of Dresden, Karl-Marx-Stadt, and Magdeburg.

This system was considerably augmented during the eighties and now nearly all establishments of higher education are comprised in it.

The many-sidedness of university and technical college graduates ensured by the system of education and training in the GDR was one of the main prerequisites for the necessary regrouping of specialists and their further specialization within the scope of further training courses. This is based on the extremely wide scope of the basic training in all disciplines. In this connection the basic training in informatics, introduced in nearly all disciplines at the beginning of the seventies should be mentioned (see Annex 1 to this chapter). It was an essential precondition of the accomplishment of tasks, particularly in the field of the application of computer technology in all branches of the national economy of the GDR.

On the basis of quite considerable effort, essential technical and technological conditions were created during the years from 1980-1985 for computerization and electronization, i.e. the large-scale introduction of information technologies. This allows the GDR, together with the other socialist countries, to tackle the demanding task of the complex programme of advance in science and technology of the CMEA member countries up to the year 2000.55

Up to the year 1990, the target envisaged is the accomplishment of the complex tasks of production and extensive introduction and application of computers of the fourth generation; they have the following

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quality marks:

- microelectronic maximum integration (LSI, VLSI);
- proximity to the place of work, process integration;
- effective, convenient interface design computer;
- high differentiation degree in the processing range, construction principle, adaptability to uses, etc;
- adaptability to inclusion in computer networks;
- efficient periphery.

In concrete terms, the XIth Party Congress of the Socialist Unity Party decided that up to the year 1990 the following should be produced and introduced:

- 85,000 - 90,000 CAD/CAM work stations;
- 160,000 - 170,000 office and personal computers;
- 1,900 - 1,950 minicomputers; and
- 660 - 670 electronic data processing installations (larger computers).

In this way the necessary measures in the fields of initial and further training assume new dimensions at all levels. The high standards of education of GDR workers, the numerous facilities for education and training and the clear statements on future demands offer favourable conditions for the achievement of this qualitatively new advance in the development of productive forces. It must be underlined that—also according to international experiences—the educational

investments in connection with such programmes should not be underestimated. Thus in Japan for instance, one-third of the investments in the national programme of computer development in the fifth generation are allocated to the corresponding training of specialists at all levels.

5.2 The contribution of the different educational institutions to the development of the specific potential of research workers for automatic data processing

The progress of society, science and technology, the rate of which is decisively influenced by information technologies gives rise to new general scientific demands on specialists. These, as well as the specific professional demands arising from this work, must be taken into account in the training provided.

The development and application of electronic computer technology gave rise to a requirement for specialists with particular abilities to promote the further advance of technology, to ensure the effective utilization of the equipment, its operation and servicing and the preparation of specific professional problems for data processing. New branches of training had to be introduced at institutions of training for skilled specialists, technical college and university graduates in professions developed with the extended application of computers.

During the fifties and sixties, a comprehensive programme of data processing was launched. At the beginning there was a shortage of trained specialists in this field. All educational institutions endeavoured to close this gap by offering various forms of further education courses of lectures, post-graduate studies, etc.

A broad and solid basic training, particularly in mathematics and the natural sciences which even at that time were the main components at all levels of education, may be considered as good preparation in this direction. This encouraged skilled specialists, graduates of technical colleges and higher education establishments to make use of available facilities to improve their qualifications, with a view to preparing for work in the field of data processing. At the present time as well, the requirements in specialists for the development and application of modern computer technology in the GDR can only be provided for by
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an effective use of all capacities for initial and further training. This is the result of the rapid rate of qualitative changes in computer technology and the relevant scope for extensive applications.

This has confronted all experts employed in the national economy with the task of permanently continuing their education and training in the fields of the development and application of modern information processing, with a view to the rationalization of their work. Further training in this field has acquired equal importance with initial training and education.

In the meantime, a wide range of further education facilities have been made available; they comprise basic courses in informatics or specific fields of informatics, and courses on the latest findings of research, which require preliminary knowledge and experience of professional work in informatics.

Some universities and similar institutions, such as the Technical Universities in Dresden and in Karl-Marx-Stadt, have developed into centres of further training in these subjects since the sixties. Furthermore a number of industrial combines, such as Robotron, provide training courses in aspects of informatics with a specifically practical orientation. The computer centres of the universities and similar institutions have made a specific contribution to ensuring the necessary unity of theoretical and practical education and training. Originally the computer centres had conducted the practical training of students at the computer within the framework of their courses of studies. At present the situation is changing, since the scientific departments of the institutes of higher education have opened computer laboratories during the eighties, which have largely taken over that function.

Co-operation between the institutes of the universities, the Academy of Sciences and the combines of the national economy is gaining in significance as regards the initial and further training in informatics and its various aspects of application of a high scientific standard and with an orientation towards practical requirements. Relations of a new quality are developing on the basis of contractual agreements, partly founded on long years of experience. Differentiated forms of co-operation are used to this effect, which provide favourable conditions also for the training of efficient research specialists for automatic data processing.

Programmes in informatics and the ability to handle computers were gradually introduced at all levels of education, from the polytech-
nical high school to vocational training courses, technical colleges and universities; these also comprise the necessary mathematical foundations. That process was intensified as from the beginning of the eighties. This is reflected, among other things, by the following changes:

- In the polytechnical high school the aim is to provide pupils with a general comprehension of informatics and elementary skills in handling computers. Thus the electronic pocket calculator was introduced as from the 7th class of instruction, and working-groups for pupils interested in informatics and computer technology were created. At the special schools for mathematics and natural sciences, informatics have been introduced as a compulsory subject as from the 9th class, in which a programming language and the handling of computers are taught. Optional compulsory subjects are intended to consolidate the knowledge about the use of computers. At matriculation level computers are used in practical scientific work, and at present optional informatics instruction is being tested.

- A new curriculum is being introduced in vocational training during the years from 1986 to 1990. This envisages the training of all apprentices in the rudiments of automation in a compulsory subject of instruction, which is further consolidated in special courses for certain occupations. New vocational demands were taken into account by the modification of the system of classification of apprenticed trades. This also includes the elaboration of aims and contents of training for a number of new apprenticed trades.

- The training of engineers and economists at technical college and university level is restructured on the basis of professional work and requirements. Starting with the 1986 academic year, training in informatics will be tested in four directions (see section 5.4. and Annex 5). The objective of this training is the qualification of engineers for the development of basic and standard software. The training in informatics for the other engineering disciplines and for economists will be differentiated with an orientation for developers and one for users. These directions in training are
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being developed on the basis of international experiences and in co-ordination with the other socialist countries within the framework of the CMEA.

The elevation of the general training level in informatics, as a prerequisite of the ability to handle computers, is at the same time regarded as a prerequisite in the preparation of a potential of efficient research specialists. Great efforts in the training of the required teaching staff are necessary to guarantee a training in informatics at all levels of education in the GDR. The facilities of the various educational institutions are being used to this effect. At present training colleges are preparing teachers in informatics for general and extended high schools, and there is a growing demand for such in all educational establishments. The formation of university teachers in informatics constitutes a focal point, since this creates the conditions for the training of highly skilled specialists capable of outstanding achievements in scientific research and the practical application of its findings.

The problems generally arising in the training of young scientific workers are particularly acute as regards informatics due to the fast rate of advance in this discipline. Considerable efforts are therefore necessary to meet the constantly increasing requirements for university teachers in this field.

5.3 Content and structure of the training of university teachers in informatics

Different professional requirements arise with the construction of computer centres at enterprises and institutions of the national economy. These are taken into account in training at various levels of education. Specialists for the operation and maintenance of computers were trained as from the beginning of the sixties. In the meantime, training courses for specialists in data processing of a high standard have been introduced for school-leavers of the 10th class. Such training may be followed up by a course of studies in informatics at the technical college in Gorlitz. Leavers of the extended high school may study informatics at a university or similar institution. Up to 1986, informatics could be studied at the Technical University in Dresden or the university-level College of Engineering in Dresden. As from the
academic year 1986-1987 there will be further training facilities in this subject at the universities in Rostock and Karl-Marx-Stadt and at the Technical University in Magdeburg.

At the beginning of the sixties, basic courses in data processing were introduced at technical colleges, in order to enable skilled specialists in various fields to make use of computers in their work. The demand for specialists of technical college standard with consolidated knowledge of mathematics and substantiated skills in utilizing information technology was evident at a very early stage. These specialists were to be able to handle computers to the extent of assisting mathematicians and other graduate specialists in the effective application of computers. The training enabled them to carry out independent programming of certain aspects of problems and testing of a computer. In compliance with these objectives, technical assistants in mathematics were trained at several institutions of higher learning during the years from 1958-1978. The content of these training programmes proved successful. It represented a transitional form of training, because it took place at university institutions but did not lead to the completion of university education.

In 1969, training courses for data processing engineers (at the College of Engineering in Görlitz) and for graduate engineers (at the Technical University in Dresden) were started through full-time and correspondence courses. The conditions for admission to a technical college was a completed vocational training in data processing. In accordance with practical requirements training courses at university level were also conducted in data processing, with a differentiated volume and content, in compliance with the different specializations for all disciplines (see Annex 1).

Within the multilateral government commission for computer technology of the socialist countries, a council of specialists for initial and further training of MIS/CAE specialists, and international curricula for MIS/CAE specific fields of instruction, were created on the basis of an international specialist nomenclature. This largely corresponds to the existing nomenclatures of training in higher education of the socialist countries and is valid up to the present time (see Annex 2). These specialists constitute the potential ensuring the advance of informatics in all its disciplines and the interdisciplinary solution of complex problems of application.

Four groups of specialists have been defined on the basis of the differentiated demands arising from the development and application of
automatic information systems in the national economy. The different aims of training for these groups of specialists are determined by differences in volume and content of the MIS/CAE specific fields of instruction. Generally studies are sub-divided as follows:

- general education subjects,
- physics and mathematics,
- economics and organization,
- general technology subjects,
- MIS/CAE disciplines (see Annexes 3 and 4).

In accordance with the objectives of training, the following branches of studies were envisaged:

- Specialists for the development, production and maintenance of technology (specialists group III, see Annex 2). The required specialists were and continue to be trained within the scope of the disciplines of electrical engineering. Examples are the disciplines 'information technology and instrument technology' and 'technical cybernetics and automation technology'. The training enables students to develop electronic assembly groups, instruments and plants, and to produce, service and maintain them.

- Specialists for the development, adaptation and utilization of programme technological means, and for the analysis and synthesis of information systems (specialists group II, see Annex 2); these specialists are trained within the scope of the discipline of informatics. (For the present structure of studies see Annex 5). In this connection it should be underlined that an equivalent training has been taking place for the past twenty years within the scope of the discipline of mathematics, in the subject 'mathematical cybernetics/computer technology'. These specialists are mainly employed in the development and rational elaboration of operational and user software in all spheres of the national economy.

- Specialists for the economical, organizational and informational substantiation of automatic information systems (specialists group I, see Annex 2); they are trained in subjects such as 'mathematical methods of data processing in the economy'. The aim of the training consists in enabling students to assist in preparing and
implementing the rational use of electronic data processing for economic and operational tasks of management and planning, including production guidance and control.

- Specialists for the development and application of automatic information systems in all branches and areas of the national economy (specialists group IV, see Annex 2); for these tasks, specialists in information processing are trained, for example, in 'information processing in building' (see Annex 4). The aim of the training consists in enabling the students to develop and effectively use specific software.

In addition, all students of the disciplines mathematics, natural sciences, economics and technological sciences are enabled, through a basic course of informatics, to utilize the computer technology available to them in the process of work as a tool. That basic training takes place within the scope of differentiated curricula for these disciplines (see Annex 1).

5.4 Selection and vocational orientation in the creation of a research potential in the field of informatics

On the basis of international and national analysis of the demands arising from the development and use of computers in all areas of social life - elaborated by the scientific advisory council for informatics—the GDR will start into the nineties with the following situation:

- 4 to 5 per cent of all employed will be specialists in informatics at various levels of education;

- 15 per cent of all employed will have knowledge and abilities in the field of informatics, varying in accordance to their specific occupations;

- about 50 per cent of all employed must be familiar with the latest information technologies to the extent of being able to use them as a matter of daily work routine.
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These qualitatively new high demands were the basis for the transformation of the structure of initial and further training at all levels of education, in particular at technical college and university level. In general, this is now being gradually introduced.

The transformation of higher and technical education—coupled with differentiated measures in the field of informatics—is of outstanding importance, because higher and technical education:

- provides the specialists for training also at the other levels of education;
- higher education is the main basis of fundamental disciplinary and interdisciplinary further training—including graduation—and not least, because it plays a vital part in the creation of the potential of specialists for research and development in the field of informatics and all its areas of application.

The speed of the advance of informatics and its application is decisively influenced by the extent to which scientific preliminary conditions for the application of informatics can be provided, in informatics and the respective special disciplines. That is why the specialists must above all be able to design information processes of the field of application or specialization, to create and further develop information systems.

A vital task of informatics specialists arises from the fact that according to international forecasts the costs of software in the automation projects envisaged for the nineties will make up a proportion of 80 to 90 per cent of the total expenditure. This means that laws, methods and means of work for the production of software will have to be found and applied, so that software technology must be developed as a specific branch of the discipline ‘informatics’.

In planning the training of engineers and economists in the field of informatics it was envisaged that specialists for the development of basic and standard software should be trained within the scope of the subject ‘informatics’, and those for software for more specific uses should be trained in the respective fields of application (e.g. ‘economic informatics’).

Training programmes and skeleton plans of studies are available for informatics training in technical subjects, intended to guarantee a thoroughgoing and differentiated training process. A distinction is made between a user-oriented and a development-oriented training. All
students of technological subjects must learn how to apply the means and methods of informatics in the practice of their specific subjects. Approximately 15 per cent of the students of a technological subject receive a more specialized training with the aim of being able to develop and introduce CAD/CAM solutions in their special branches and fields.

The specific profiles of the different universities and similar institutions and their relations with industrial combines are taken into account in this connection. Such relations and relevant agreements also form an important basis for long-term plans for the development of university teachers and graduate specialists.

A programme was developed for informatics training in the subject of economics, in accordance with the respective requirements, which is composed of the following four stages:

- thorough informatics training for all students;
- concentrated informatics training for approximately 15 per cent of the students;
- training in economics informatics;
- further training courses in informatics for economists.

In contrast to the mainly undifferentiated training of informatics specialists (engineers and graduate engineers for informatics) a subdivision into four subjects (see Annex 5) was introduced. These correspond with the distinct main fields of activities of informatics specialists. Accordingly, engineers will be trained, as from 1986, in the following fields:

- the further development of the theoretical foundations of informatics;
- the development of basic software;
- the development of information and control systems as a means of rationalization and automation of data processing;
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• the planning and operation of computer systems and computer-based communications systems.

All four subjects comprise a general standard and a specific part, which is followed up by the specific part of the training in the respective discipline of study (see Annex 5). Further specializations are envisaged in the scope of the disciplines, described as consolidating studies, depending on the research profile at the university or higher education institute in question. The whole training is envisaged as a course with a balanced proportion of theoretical foundations and practical skill. As in all other branches of studies, relevant vocational knowledge and practical experience are also required in informatics. This relates above all to the programming and use of computers. The preliminary knowledge and skills are acquired within the framework of preparation for studies. Varied periods of studies are envisaged for the training in each of the four directions up to qualification as an engineer.

In accordance with the requirements for developing a potential of adequately qualified specialists for the necessary informatics research and the systematic user-oriented research, capable students must be led up to graduation. Experience previously acquired in the organization of studies can be used in this connection.

The accomplishment of the demanding tasks to ensure the training of young scientific workers for the national economy, and for the Academy of Sciences and higher education institutions, calls for a systematic and differentiated training and further qualification of higher education teachers, in particular in the field of informatics, with its extremely fast rate of advancement. University teachers are ultimately responsible for ensuring that the unity of learning and research, a thorough initial and further training, and the careful selection and training of specialists is guaranteed.
ANNEX 1

Phased programme of basic training in electronic processing and information processing (1)

<table>
<thead>
<tr>
<th>Content</th>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
<th>Phase 4 (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Elaboration of algorithms</td>
<td>8</td>
<td>20</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Data processing technology</td>
<td></td>
<td>5</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Programming languages</td>
<td>3</td>
<td>2</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Methodology of data processing/project</td>
<td>2</td>
<td>8</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Experiences and development trends in data processing; application in specific fields</td>
<td>5</td>
<td>8</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>45</td>
<td>90</td>
<td>260</td>
</tr>
</tbody>
</table>


(2) Phase 4 presumes the successful conclusion of Phase 3, and serves specialization in the field of application of electronic data and information processing with the following training content:

<table>
<thead>
<tr>
<th>Number of hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programming techniques and technology</td>
</tr>
<tr>
<td>Projection and application of information systems</td>
</tr>
<tr>
<td>Selected chapters of the mathematical foundations of the application of electronic data processing</td>
</tr>
</tbody>
</table>
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ANNEX 2
MIS/CAE specialists nomenclature and surveys of specific training for selected subjects of this nomenclature

The term ‘MIS/CAE’ denotes the facts relevant to the comprehensive use of computers and other means of automation for automatic information processing in management and control of production, constructive and technological preparation of construction, etc. Within the multilateral government commission for computer technology of the socialist countries, the council of specialists for the initial and further training of MIS/CAE specialists has, during the course of several years of work, drawn up international training programmes for information processing subjects. To begin with an international nomenclature of MIS/CAE specialists was worked out, which largely corresponds with existing training nomenclatures of the different socialist countries.

MIS/CAE specialists nomenclature:

- **Specialists group I**: specialists for the organizational, economic and informational prerequisites of MIS/CAE; subjects ‘mathematical methods and data processing in the economy’, ‘economics informatics’;

- **Specialists group II**: specialists for the mathematical and programming prerequisites of MIS/CAE; basic subject ‘informatics’;

- **Specialists group III**: specialists for the technological prerequisites of MIS/CAE; including the subject ‘information technology’;

- **Specialists group IV**: specialists in the development and application of MIS/CAE in branches and areas of the national economy:

  (a) **group IVa**: MIS/CAE specialists in branches and areas of the national economy, e.g. the subject ‘information processing in building’;

  (b) **group IVb**: MIS/CAE users in branches and areas of the national economy, e.g. basic training in informatics and its consolidation in specific aspects.
We give below a survey of MIS/CAE specific subjects for the specialist groups I, II, IVa and IVb, showing the disciplines and recommended numbers of hours of instruction.

Survey of MIS/CAE specific subjects - specialists group I

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Recommended number of hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>- MIS/CAE projection</td>
<td>98 - 140</td>
</tr>
<tr>
<td>- Organization and technology of mechanical information processing</td>
<td>106 - 130</td>
</tr>
<tr>
<td>- Programming and programming language</td>
<td>120 - 200</td>
</tr>
<tr>
<td>- Operational systems and programming packages</td>
<td>80 - 120</td>
</tr>
<tr>
<td>- Information theory</td>
<td>50 - 106</td>
</tr>
<tr>
<td>- Theoretical foundations of management systems</td>
<td>60 - 80</td>
</tr>
<tr>
<td>- MIS/CAE reliability and effectiveness</td>
<td>36 - 72</td>
</tr>
<tr>
<td>Total number of hours</td>
<td>550 - 848</td>
</tr>
<tr>
<td>(4,500 hours = 100%)</td>
<td>12 - 19%</td>
</tr>
</tbody>
</table>
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Survey of MIS/CAE specific subjects - specialists group II

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Recommended number of hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Projecting and development of MIS/CAE</td>
<td>98 - 140</td>
</tr>
<tr>
<td>- Organization and technology of mechanical information processing</td>
<td>106 - 130</td>
</tr>
<tr>
<td>- Programming and programming languages</td>
<td>300 - 600</td>
</tr>
<tr>
<td>- Operational systems and programming packages</td>
<td>90 - 180</td>
</tr>
<tr>
<td>- Information theory</td>
<td>60 - 90</td>
</tr>
<tr>
<td>- Theoretical foundations of MIS/CAE</td>
<td>60 - 80</td>
</tr>
<tr>
<td>- Computer and algorithm theory</td>
<td>60 - 120</td>
</tr>
<tr>
<td>- Digital graphics</td>
<td>20 - 48</td>
</tr>
<tr>
<td>- Organization of data banks</td>
<td>50 - 120</td>
</tr>
<tr>
<td>- System modelling</td>
<td>98 - 140</td>
</tr>
<tr>
<td>Total number of hours</td>
<td>940 - 1648</td>
</tr>
<tr>
<td>(4,500 hours = 100%)</td>
<td>21 - 37%</td>
</tr>
</tbody>
</table>
Survey of MIS/CAE specific subjects - specialists group IVa

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Recommended number of hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Theoretical foundations of MIS/CAE</td>
<td>120 - 300</td>
</tr>
<tr>
<td>- System analysis</td>
<td>45 - 90</td>
</tr>
<tr>
<td>- System modelling</td>
<td>75 - 150</td>
</tr>
<tr>
<td>- Programming, programming languages and operational systems</td>
<td>75 - 150</td>
</tr>
<tr>
<td>- MIS/CAE instrument technology</td>
<td>75 - 300</td>
</tr>
<tr>
<td>- Organization and technology of mechanical information processing</td>
<td>0 - 90</td>
</tr>
<tr>
<td>- Information theory</td>
<td>60 - 75</td>
</tr>
<tr>
<td>- MIS/CAE Projection and application</td>
<td>90 - 150</td>
</tr>
<tr>
<td>Total number of hours</td>
<td>540 - 1305</td>
</tr>
<tr>
<td>(4,500 hours = 100%)</td>
<td>12 - 29%</td>
</tr>
</tbody>
</table>
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Survey of MIS/CAE specific subjects - specialists group IVb

- Theoretical foundations of MIS/CAE 75 - 120
- System analysis 60 - 90
- Technological MIS/CAE means 60 - 75
- Programming 45 - 60
- Foundations of MIS/CAE projection and application 60 - 105

Total number of hours 300 - 450
(4,500 hours = 100%) 7 - 10%
ANNEX 3
Proportion of training in MIS/CAE (1) specific subjects in various disciplines

<table>
<thead>
<tr>
<th>Specialists group/ training aim</th>
<th>Discipline (Example)</th>
<th>Recommended proportion of MIS/CAE specific subjects in the total training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specialists group I</td>
<td>Mathematical methods and data processing in the economy</td>
<td>12 - 19%</td>
</tr>
<tr>
<td>Economics, organizational and informational prerequisites of MIS/CAE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specialists group II</td>
<td>Information processing, informatics (2)</td>
<td>21 - 37%</td>
</tr>
<tr>
<td>Mathematical and programming technological prerequisites of MIS/CAE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specialists group IVa</td>
<td>Information processing in building (2)</td>
<td>12 - 29%</td>
</tr>
<tr>
<td>Development and application of MIS/CAE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specialists group IVb</td>
<td>Basic training in informatics in all technological, economics disciplines</td>
<td>6 - 10%</td>
</tr>
<tr>
<td>Application of MIS/CAE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(1) See Annex 2
(2) Structure of studies, see Annex 4
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ANNEX 4
Structure of selected courses of studies - from the aspect of the consideration of the proportion of MIS/CAE (1) specific subjects (in %)

<table>
<thead>
<tr>
<th>Training complex</th>
<th>Informatics</th>
<th>Information processing in building</th>
<th>Engineering construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>- General foundations (Marxism-Leninism, foreign</td>
<td>22</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>languages, sports)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Basic physics and mathematics</td>
<td>20</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>- Basic economics and organizational techniques (e.g.</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>operational management, labour theory)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Technological foundations</td>
<td>5</td>
<td>40</td>
<td>44</td>
</tr>
<tr>
<td>- Foundations in informatics</td>
<td>22</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>- MIS/CAE specific disciplines</td>
<td>21</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>- Available time of the faculty (2)</td>
<td>5</td>
<td>8</td>
<td>15</td>
</tr>
</tbody>
</table>

- (1) See Annex 2
- (2) This time serves the specialization and is taken up by the faculty responsible for the training.
**ANNEX 5**

*Content and structure of the future training in the basic discipline 'informatics'*

<table>
<thead>
<tr>
<th>Training complex</th>
<th>Theoretical informatics</th>
<th>System software</th>
<th>Applied informatics</th>
<th>Computer system dev. &amp; operation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

% of training complex in the total number of hours

1. General foundations
   - Basic economics and organizational techniques: 19 (1) 20 (1)
   - Mathematics: 5 11
   - Basic physics and electronics: 6 7

2. General foundations in informatics: 16 18

3. Specific training: 11 8 8 7

4. Time available to the institute:
   - Basic training: 34 31 31 32
   - Specialized training
   - Computer laboratory

(1) For the discipline 'theoretical informatics' a larger number of hours are envisaged. Training complexes 1 and 2 will be taught with the same number of hours in all four disciplines.
Content differentiation of disciplines

Within the training disciplines, lectures on the following subjects are envisaged:

<table>
<thead>
<tr>
<th>Theoretical informatics</th>
<th>System software</th>
<th>Applied informatics</th>
<th>Computer system development and operation</th>
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</thead>
<tbody>
<tr>
<td>Philosophical and social aspects of informatics</td>
<td>System software</td>
<td>Information</td>
<td>Computer networks</td>
</tr>
<tr>
<td>Functional and logical programming</td>
<td>Theory of programming languages and language implementation</td>
<td>Modelling simulation</td>
<td>Technology of computer operation</td>
</tr>
<tr>
<td>Methods of artificial intelligence</td>
<td>System draft and evaluation</td>
<td>Data banks II</td>
<td>Computer and communications technology</td>
</tr>
<tr>
<td>Theoretical informatics</td>
<td></td>
<td>Software implements</td>
<td>System programming</td>
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<tr>
<td>Computer architecture</td>
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