Technical and Vocational Education and Training– Curricula Reform Demand in Bangladesh. Qualification Requirements, Qualification Deficits and Reform Perspectives

Von der Fakultät Wirtschafts- und Sozialwissenschaften
der Universität Stuttgart zur Erlangung der Würde eines
Doktors der Philosophie (Dr. phil.) genehmigte Abhandlung

Vorgelegt von

Md. Faruque Ahmed

aus Barisal, Bangladesh

Hauptberichter:	Prof. Dr. Reinhold Nickolaus
Mitberichter:	Prof. Dr. Bernd Geißel
Tag der mündlichen Prüfung:	20. Dezember 2010

Institut für Erziehungswissenschaft und Psychologie

2010

für Judith

Acknowledgements

I would like to thank all those people who made this dissertation possible. Without their help and constant support I could never have completed this work.

First of all, I would like to give my thanks to my advisor, Prof. Dr. Reinhold Nickolaus. Without his advice and guidance this dissertation would not have been possible. Not only was he readily available for me, as he so generously is for all of his students, but he always read and responded to the drafts of each chapter of my work more quickly than I could have hoped. His oral and written comments are always extremely perceptive, helpful and appropriate. Of course, despite all the assistance provided by Prof. Nickolaus and others, I alone remain responsible for the content of the dissertation, including any errors or omissions which may unwittingly remain.

I am particularly thankful to Prof. Dr. Bernd Geißel who gave me valuable advice, especially in analysing curriculum content, exam questions, and constructing the test.

My enormous debt of gratitude can hardly be repaid to Dr. Astrid Diener, Ms. Marie-Luise Latteyer, Tobias Gschwendtner, Stephan Abele and, lastly, Khatuna Chanturia, who not only proof-read multiple versions of this dissertation, but also provided many suggestions to help me improve my presentation and clarify my arguments.

I am very much thankful to Anke Treutlein, who actively helped me in quantitative data analysis using SPSS and also translating English to German and vice versa.

My thanks also goes to Dr. Martin Kenner, Dr. Sabine K. Lehmann-Grube, Alexander Nitzschke, Kerstin Norwig, Cordula Petsch, Annette Gönnenwein , Annika Boltze, Anne Windaus, Svitlana Mokhonko, Anja Sarnitz, Andreas C. Lazar, Margrit Öhler und Monica Weiser-Suhr.

I gladly express my gratitude to my good friend Balaji Devaraju for his practical support on intelligently handling problems concerning Latex.

My thanks go to Cristina Postolache and Alex Vasilie who helped me in proof-reading and giving support in many different ways.

For this work I also had a lot of supports and inspiration from my family, friends and colleagues. Some, but not all, are Mr. Shahjahan Miah, Dr. Khan Rezaul Karim, Ruhul Amin, M.A Hannan, Ruhul Alam, Bounpanh Xaymountry and others. I am very much grateful to all of them for all kinds of supports and continuous inspiration they have given to me to do this work.

Zusammenfassung

Berufliche Aus- und Weiterbildung (Englisch: Technical and Vocational Education and Training [TVET]) hat in Bangladesch in den letzten Jahrzehnten zunehmend an Bedeutung gewonnen. Das Programm “Diploma-in-Engineering” des TVET wird in Bangladesch an den Polytechnics Instituten angeboten und führt zu einem technischen / beruflichen Abschluss auf mittlerem Niveau. Die Dauer dieses Programms wurde 1999 von drei auf vier Jahre erhöht, um die Qualität der Ausbildung den internationalen Standards anzugleichen. Zudem wurde der Lehrplan überarbeitet. Bislang wurde im Bereich der Berufsbildung weder die Kompetenz der Auszubildenden erfasst, noch auf regionaler oder gar internationaler Ebene verglichen.

Die vorliegende empirische Studie untersucht den Lehrplan des “Diploma-in-Engineering” für Elektronik Technologie inklusive der Inhalte der Abschlussprüfung sowie der Lernergebnisse. Diese Aspekte werden mit der Ausbildungspraxis im Dualen System Deutschlands verglichen. Die Studie überprüft zudem die Fähigkeit von Lehrkräften, einzuschätzen, ob ihre Schüler / -innen vorgegebene Aufgaben richtig lösen können. Außerdem werden die Leistungsunterschiede zwischen einzelnen Schulen und Klassen untersucht.

Um diesen Themenkomplex zu untersuchen, wurden Lehrkräfte mit einem selbst entworfenen Fragebogen befragt. Schüler / - innen wurden mit einem selbst entwickelten Leistungstest untersucht. Zudem wurden Gespräche mit Experten, Dozenten und Schlüssel-personen, sowie mit einigen Auszubildenden geführt. Insgesamt wurden jeweils 160 Auszubildende an Berufsschulen in Baden-Württemberg und an *Polytechnic Institutes* in Bang-ladesch untersucht. Der Zeitraum der Datenerhebung erstreckte sich von Juli 2009 bis Februar 2010. In den Leistungstests wurden hauptsächlich die technischen Fähigkeiten der Auszubildenden, vor allem im Hinblick auf praxisrele-

vante Aufgaben, erfasst. Um die Hypothesen zu überprüfen, wurden die Daten sowohl quantitativ als auch qualitativ ausgewertet (Section 3.2, p. 61).

Die Ergebnisse des Leistungstests zeigen, dass die Auszubildende aus Bangladesch einen erheblichen Rückstand gegenüber ihren deutschen Kollegen aufweisen: Die Auszubildenden an den Polytechnics in Bangladesch erzielen nur ein Viertel der Punkte der Auszubildenden in Deutschland. Diese Ergebnisse bestätigen die Aussagen der Experten und Dozenten aus Bangladesch, die Zweifel an der praktischen Kompetenz der Schulabgänger äußern. Als Grund dafür sehen sie mangelnde Vorkenntnisse und Grundfähigkeiten am Anfang der Ausbildung. Sie beklagen auch das Fehlen von motivierten Lehrkräften. Jedoch spielt das Lernumfeld, das u. a. durch den Komplexitätsgrad des Curriculums charkterisiert ist, eine wichtige Rolle hinsichtlich der Kompetenzentwicklung der Auszubildenden. Ein unangemessener Lehrplan (zu komplex, zu simpel oder nicht ausgewogen) kann die Entwicklung der Kompetenzen der Auszubildenden negativ beeinflussen [Nickolaus, 2008, p. 10; vgl. Knöll, 2007, p. 123].

Die Kompetenzen der Auszubildenden auf unterschiedlichen Ebenen kognitiver Prozesse wurden ebenfalls untersucht. Die Ergebnisse zeigen, dass Aufgaben, die lediglich eine Wissensreproduktion erfordern (Stufe 1: Erinnern), mit einer höheren Wahrscheinlichkeit richtig gelöst werden, als Aufgaben, die einen Transfer und / oder eine Anwendung des Wissens erfordern (Stufe 3: Anwenden). Die Leistungen der Auszubildenden bei Aufgaben, die Reproduktion (Erinnern) erfordern und bei Verstehensaufgaben (Reorganisation von Wissen) fallen vergleichbar aus.

Ein Vergleich der Leistungen auf unterschiedlichen kognitiven Ebenen in Bangladesch und Deutschland zeigt, dass die Studierenden aus Bangladesch vergleichsweise schwach abschneiden, während deutsche Auszubildende auf allen drei Ebenen gute Ergebnisse erzielen. Die Länderunterschiede bei Aufgaben zum Anwenden und Verstehen fallen größer aus als bei Aufgaben der Kategorie Erinnern.

Der Leistungstest (mit 16 Aufgaben) zur Erfassung der Kompetenz der Auszubildenden wurde den Lehrkräften mit der Bitte vorgelegt, einzuschätzen, ob ihre Schüler/-innen die Aufgaben lösen können. Es zeigte sich, dass die Lehrkräfte in den meisten

Fällen die Aufgaben hinsichtlich ihrer Schwierigkeit zutreffend ordnen konnten, sie aber die Leistung der Studierenden überschätzten.

Sechs Klassen aus fünf verschiedenen Polytechnics in Bangladesch nahmen an der Untersuchung teil. Obwohl alle fünf Schulen denselben Lehrplan hatten, zeigte sich ein bedeutsamer Unterschied in den Schülerleistungen der einzelnen Schulen. Die Tests haben gezeigt, dass die Polytechnic Institutes innerhalb der Hauptstadt wesentlich bessere Leistungen als diejenige außerhalb Dhaka erzielt haben. Die TVET-Programme sind zentral überwacht, ausgehend von Dhaka.

In Deutschland nahmen elf Klassen aus sieben Berufsschulen an der Studie teil. Auch diese Klassen unterscheiden sich deutlich in ihrem Leistungsniveau, wobei es einzelne Schulen / Klassen gibt, deren Leistungen vergleichbar ausfallen. Berufsschulen aus Deutschland folgen einem flexiblen Lehrplan.

Desweiteren konnte festgestellt werden, dass die Anforderungen in den Abschlussprüfungen in Bangladesch und Deutschland hinsichtlich theoretischen Wissens und praktischer Relevanz stark differieren. So wird in Bangladesch mehr Wert auf theoretisches Wissen gelegt und im Vergleich zu Deutschland spielen Transferaufgaben eine untergeordnete Rolle. Das Lernfeld-orientierte Curriculum in deutschen Berufsschulen legt Wert auf praxis-orientiertes Lernen und Lehren und fördert die Fähigkeit der Auszubildenden für Wissenstransfer.

Als zentrales Ergebnis konnten in dieser Studie Stärken und Schwächen des “Diploma-in-Engineering” - Programms in Bangladesch aufgezeigt und darauf aufbauende Veränderungsvorschläge entwickelt werden.

Beachtet werden sollte jedoch, dass selbst bei einem qualitativ hochwertigen Curriculum die Lernergebnisse von der Umsetzung des Curriculums abhängen, genauso wie von institutionellen und individuellen Kontextfaktoren. Diese Variablen sollten in zukünftigen Studien mehr Beachtung erhalten.

Abstract

Technical and Vocational Education and Training (TVET) has been expanding for the last decades in Bangladesh. The *Diploma-in-Engineering* programme of TVET in Bangladesh is offered through polytechnics and leads a middle level technical / vocational qualification for technicians (*Diploma engineers*). The duration of this programme has been increased, from three years to four years in 1999 in order to improve the quality of *Diploma engineers* with regard to international level standards. The curriculum has been reviewed. A student competency assessment in the TVET sub-sector and a comparison at intercontinental or regional level has not been made yet.

This empirical study investigates the *Diploma-in-Engineering (Electronics Technology)* curriculum including student assessment approach and learning / teaching outcomes, and compares them with Germany's initial vocational training in the *Dual System*. The study also examines whether teachers are in a position to estimate students' ability to solve tasks they are set. Furthermore, it examines if the student performance differs among schools / classes.

The required data was collected through a self-designed test and a questionnaire. Consultation with experts, senior teachers, key persons and some students was made too. The survey (data collection) was conducted with vocational schools (Berufsschulen) in Baden-Württemberg, Germany (N = 160) and with polytechnic institutes in Bangladesh (N = 160) within the period from July 2009 to February 2010. The competence test measured mainly students' technical competencies, particularly in the case of practical relevant tasks. Both quantitative and qualitative methodologies were used to analyse the data and to test the hypotheses of this study (Section 3.2, p. 61).

The results of the test show that Bangladeshi polytechnic students lag clearly behind

the German apprentice trainees. The polytechnic students in Bangladesh obtained only a fourth of the points that the German vocational school trainees obtained in the competence test. These findings support experts' and teachers' opinions (who work in the TVET sector in Bangladesh), who are in doubt about the practical competences of the polytechnic graduates. They blame the lack of prior-knowledge and basic competences of students at the entry-stage of the course. They also complain that there is a lack of teachers who regard their profession as a vocation. However, the learning environment that includes, among other determinants, the curriculum complexity level, plays a significant role in developing students' competencies. An inadequate curriculum (too complex or too simple or not yet properly tuned) may hinder the development of students' competencies [Nickolaus, 2008, p. 10; cf. Knöll, 2007, p. 123].

Students' competencies at different levels of cognitive processes were examined during this study too. The findings showed that "*the tasks, which require only knowledge reproduction (level 1: the cognitive process category of Remember), are solved correctly with a higher probability than the tasks which require knowledge transfer and/or knowledge production (level 3: the cognitive process category of Apply)*". Students' performances in solving the tasks in the cognitive process category of *Remember* (reproduction) and the category of *Understand* (re-organisation) were found to be almost the same.

A comparison between the two countries at different cognitive levels was made. The findings show that the polytechnic students in Bangladesh perform poorly, whereas the trainees in Germany perform relatively well in answering the tasks at all three levels of the cognitive process. It was found that the differences in the categories of *Apply* and *Understand* were bigger than the difference in the category of *Remember*.

As mentioned above, a test (consisting of 16 tasks) was developed for students' competency measurement. The teachers were given this test prior to their students sitting it. Teachers estimated the ability of the students to solve the tasks they were set. It was found that "*in most cases, teachers were able to estimate the difficulty of the tasks in relation to the others, but they overestimated students' achievement.*"

Six classes from five polytechnic institutes participated in the test in Bangladesh. Although all polytechnics follow a common curriculum, the results showed *a significant difference of student performance among polytechnic institutes in Bangladesh.* The results of the test show that the polytechnics situated inside the capital city came off better than the ones outside of Dhaka. The results The TVET programmes are monitored centrally and the monitoring is Dhaka based.

In Germany, eleven classes from seven vocational schools took the test. In general, *the trainee performance among vocational schools in Germany differs significantly*. But there are schools/classes whose overall performances are more or less similar. Vocational schools in Germany follow a flexible and learning field based curriculum.

Furthermore, this study investigated and found that *the student assessment approaches in Bangladesh and Germany differ greatly regarding their theoretical requirements and practical relevance.* The curriculum content analysis and the analysis of student assessment approach in Bangladesh showed that the *Diploma curriculum* mainly focuses on theoretical matters. The findings of the examination questions analysis clearly indicate that little emphasis is placed on transfer-based tasks in Bangladesh compared to Germany. Germany's learning field based curriculum in vocational schools focuses on practice-oriented learning and teaching, and fosters the trainees' knowledge transfer capability.

Finally, this study identified the strengths and weaknesses of the current *Diploma-in-Engineering (Electronics Technology)* curriculum in Bangladesh, and made some suggestions to modernise it accordingly.

However, if the quality of curricula is good, then the outcomes depend on the quality of curriculum delivery processes, as well as institutional and individual context factors. It is suggested that future studies pay more attention to these named areas.

Contents

List of Figures

List of Tables

Abbreviations

BANBEIS	Bangladeh Bureau of Educational Information and Statistics
BIBB	Bundesinstitut für Berufsbildung
BTEB	Bangladesh Technical Education Board
DIN	Deutsches Institut für Normung (German Institute for Standardization)
DTE	Directorate of Technical Education
HRD	Human Resources Development
IEC	The International Electrotechnical Commission
KMK	Kultusministerkonferenz (the conference of cultural affairs ministers)
NTVQF	National Technical and Vocational Education and Training Qualification Framework
OECD	Organisation for Economic Co-operation and Development
PLC	Programmable Logic Controller; Speicher Programmierbare Steuerung (SPS)
PRSP	Poverty Reduction Strategy Papers
TVET	Technical and Vocatioanlal Education and Training
TVQF	Technical and Vocational Education and Training Qualification Framework
UNDP	United Nations Development Programme
VET	Vocational Education and Training

1. Introduction

1.1. Background

Technical and Vocational Education and Training (TVET) in Bangladesh operates at Diploma (higher secondary) and Certificate (secondary) level. For the last decades several measures have been taken, including curriculum review, introduction of new courses or occupations, extension of course duration, institutional restructuring and expansion, et cetera, in order to improve the quality and to increase the quantity of TVET graduates in Bangladesh. However, there is a deep consensus that the curriculum, particularly for the *Diploma-in-Engineering* course, is too theory oriented and it does not provide polytechnic students with adequate employable skills and knowledge. To date, however, empirical studies (either quantitative or naturalistic / qualitative) on the evaluation of the effectiveness of this curriculum are lacking. A study for its equivalence on an international level is also missing.

1.1.1. TVET in Context

Bangladesh, located in South Asia on the Bay of Bengal, bordered by India and Myanmar, is one of the world's most densely populated countries, with its 162.2 million (UN, 2009) people living in an area of 144,000 square kilometres, an area approximately equal to twice the size of Baden-Württemberg (35,751 square kilometres, 10.74 millions) plus the size of Bavaria (Bayern, 70,547 square kilometres, 12.0 millions). The population is relatively young, with the 0 - 25 age group comprising 60%, while 3% are 65 or older.

Bangladesh has 72.5 million labour force. The major employment sector of this extremely poor country is agriculture, but it is unable to meet the demand for jobs. Thus many Bangladeshis - in common with citizens from other countries in the region - seek work abroad. The country is trying to diversify its economy, with a priority of industrial development. Despite continuous domestic efforts and assistance from the international donar community to improve economic and demographic prospects, Bangladesh remains a developing nation (UNFPA, 2007). Its per capita income in 2008 was US$520 compared to the world average of $10,200 (BBC, 2010). The education expenditures are 2.7% of GDP (2005). (In Germany this figure was 4.5% of GDP). The literacy rate is also low, about 47.9% per cent (male: 54%, female: 41.4% (2001 Census)). Between 1980 and 2007 Bangladesh's human resource development index (HDI) rose by 1.86% annually from 0.328 to 0.543, which gave the country a rank of 146th out of 182 countries (UNDP, 2009).

Its natural resources include natural gas, fertile soil and water only (Website: Background Note Bangladesh (US_Departmet, 2010)). Bangladesh's main industries are ready-made garments and knitwear, cotton, textiles, tea, sugar and food processing, jute, leather, paper, newsprint, cement, chemical fertilizer, pharmaceutical products, light engineering, electrical machines (transformer only), electronic devices (power supplies, et cetera), computer assembly, more recently ship-building, et cetera. Its main exports are garments, fish, jute goods, leather products, medicine, et cetera.

1.1.2. The Importance of HRD for Bangladesh

Since Bangladesh has only limited natural resources, as mentioned above, the Human Resources Development (HRD) is one of the key issues in its national development plan. Indeed, it is believed that the real wealth of a country lies not only in its natural resources but also much in the quality of the education of its people and their ability to use their knowledge for national development (Hossain, 2008). Economists have emphasized the increasing importance of human capital as the unique factor in economic development and competition (Brown & Lauder, 1995). Jucius & Irwin (1979, p. 221), noted "*Human Resources are the most powerful propeller of a country's economic growth and development.*" An increasing focus, both in research and in the policy debate, on HRD and work based education and training as instruments for enhancing productivity, competitiveness, and economic growth have been witnessed during the last decade (Pfeffer, 1995); (Rubenson & Schütze, 1993). Ray et al. (2007, p. 15) underlined, "*the next phase of globalisation is likely to be marked by an emerging global labour market and* *societies will have to grapple with many thorny problems of labour market integration."* In a report on Technical Education in Bangladesh Oxtoby (1997) commented " *..perhaps more than any other country, Bangladesh has only human resources on which to base its future development*".

Indeed, Bangladesh's economy is largely dependent on foreign remittance. In the fiscal year of 2009 remittances from overseas Bangladeshis[1] totaling $9.7 billion accounted for almost 25% of GDP, that is just after the Garment exports, totaling $12.3 billion (CIA World Factbook).

1.1.3. Government's TVET Policies and Strategies

The focuses of the government on education as enunciated in different policies and Five Year Plan documents are (National Education Report, 2004):

- Providing value based education
- Emphasis on job-oriented and need-based education
- Modernisation of curricula
- Ensuring efficient management at all level
- Strengthening the Information and Communication Technology
- Ensuring teacher effectiveness at all levels
- Revitalising technical and vocational education
- Ensuring gender parity at all levels of education

The government has expressed in its new education policy that in an era characterized by the challenge of rapid technological change, globalisation, economic uncertainty and diminishing resources there is no alternative to education and training that comply with modern and international standards. Therefore, TVET has been assigned high priority in its current national education policy (2009). Meeting national demand the country can increase its foreign exchange earnings by exporting its skilled manpower,

[1] the citizens of Bangladesh

since there is a demand of skilled manpower in international job markets. Therefore, the government aims to train the country's huge workforce considering national and international job market requirements. Furthermore, it is planning to introduce a modern apprenticeship training programme in the country (National Education Policy 2009, pp. 17 – 18).

In the meantime, the government, together with assistance from international donor community, is preparing the National Skills Development Policy, including National Technical & Vocational Qualifications Framework (NTVQF), as key commitments to the strengthening and further growth of skills development in Bangladesh. The government has already made commitments in Poverty Reduction Strategy Paper (PRSP) II to the effect that (ILODhaka, p. 49):

a. TVET students shall comprise 20% of all secondary students (currently it is 3%);
b. Enrolment in TVET should increase by 50%; and that
c. Women's enrolment should increase by 60%.

Note: The total enrolment in TVET sub-sector is 241336 (including female 62562 (25.9%)) and the total enrolment at secondary level is 6389857 (girls 3435695 (53.77%)). The total enrolment at Diploma level at Polytechnic Institutes is 27518 (including a female enrolment of 2926 (10.6%)) (BANBEIS, 2008).

1.1.4. The Role of the DTE and BTEB in TVET

The Directorate of Technical Education (DTE), created within the Ministry of Education of Bangladesh in 1960, is one of the government agencies of human resource development (HRD) of the country in Technical and Vocational Education and Training (TVET). It administers and controls a range of facilities for technical education at various levels. Polytechnics are the single most important group of institutions managed and supervised by the DTE.

Bangladesh Technical Education Board (BTEB) is a statutory body established in 1967. It takes the responsibility for curricula and associated matters. Also it arranges for development of learning materials, grants the affiliation to the concerned institutions, conducts examinations of the students completing different courses in different areas of vocational and technical education, and awards certificates to the successful candidates, among others.

1.2. Problems

A UNDP review of post-primary education highlighted the following barriers to quality in education in Bangladesh (World Bank, 1999b):

1. Inadequate professional preparation of teachers in both subject matter and teaching methods;
2. Lack of academic supervision;
3. Inadequate attention to research;
4. Lack of teacher and institutional accountability; and
5. Insufficient and unsuitable textbooks.

Bangladesh Education Sector Review 2000 (World Bank, 2000) elaborated that the main problem with skills training in the formal and non-formal sector of TVET is lack of linkages to employers and the job markets. Employers complain that training programmes do not produce the skills they require. They typically do not participate in determining contents of training programmes. Courses tend to be offered in response to social demands, not based on labour market surveys and analysis. Labour market information is not collected systematically. There is no adequate database for labour market analysis, policy formulation, and research in TVET. Employers complain that the government is unable to change curricula quickly to keep up with technological changes in enterprises (ibid.).

Khanam & Shamsuddoha (2003) identified the following problems of developing human resources in Bangladesh:

Lack of Government Initiative. While the government says it supports human resource development it does not provide adequate funding. There is no nation-wide research regarding the quantity and quality of HRD programmes.

Lack of infrastructure. While educational institutions may offer strong programming to develop valuable and salable skills, they lack the facilities to deliver these programmes in an efficient and effective manner.

Lack of Quality. The quality of these institutions is very uneven. Some do not provide quality teachers, materials or other resources needed for students to succeed. The government is casual in its oversight of programmes.

Lack of Co-ordination. Human resource development activities are not well coordinated. There is no coordination among the primary, secondary, and tertiary education systems. The quality, syllabus structure, teaching methodologies, styles, and facilities for the same courses or topics differ from institution to institution.

Lack of investment. Both the government and private sector provide few resources for HRD in Bangladesh. HRD progammes are handicapped by the scarcity of funds.

Lack of trained instructors. Experienced, efficient, and trained instructors or teachers are a rarity in Bangladesh. In addition the lack of funding makes it difficult to hire qualified instructors.

Lack of Facilities. Technologies to support learning (Multi media, OHP, Internet, Computerized programmes, and other audiovisual devices) are almost absent in Bangladesh. This lack of facilities constrains the development of HRD programmes.

Lack of Communication. The teacher student communication, particularly out of classroom / routined lecture, is seldom. This is mainly because teachers at public institutions are not checked for their accountability. There are no teachers' performance assessment, HRD programmes monitoring and evaluation systems in Bangladesh. Hence there is little opportunity to make improvements to the programmes.

Improper Licensing. Government has approved so many institutions for human resource development without any given directives or guidelines. This lack of standards allows opportunities for running fraudulent programmes.

Particularly in the TVET sub-sector, there are further problems such as insufficient student competencies (key or basic competences) at entry-level (input stage), the TVET curricula are not modern and effective[2] enough, lack of devoted instructors, extremely insufficient instructors, insufficient laboratory equipment; insufficient (in some cases, not at all) self-learning facilities at training institutes (for example using information and communication technology (ICT), institute library and laboratory resources), inferior quality of instruction (curriculum delivery), inefficient usage of industrial attachment periods, et cetera.

However, the competencies of polytechnic graduates have been deteriorating due to many reasons for long. The graduates are hardly able to secure jobs in their relevant fields in national and international job markets.

Since 2001 BTEB has extended the former *Three-Year Diploma-in-Engineering* courses to *Four-Year Diploma-in-Engineering* courses . One of the clear objectives has been to impart more practical and workplace relevant skills, knowledge and abilities to the students and, thus, improve the quality of polytechnic graduates. It remains yet to be proved, whether this extension has added to the quality of the polytechnic graduates or not, but one can immediately understand that this change has imposed an extra financial burden both on the government and the clientele.

In the current programme, out of 8 semesters (4 years) one semester is fully devoted to industrial attachment training, in which students undergo 12 weeks of practical training at enterprises/ industries and 4 weeks of practical training at laboratories of their own polytechnic institutes. Previously this industrial attachment training was only a half-semester. With a recent review BTEB has adapted the Diploma level curriculum content, so far, to the technological changes and labours market requirement. This inclusion of new subjects/ contents has enlarged the curriculum content volume and added new problems such as students are often overburdened and they often have to face tough challenges in passing the (final) examination. Therefore, they usually cram for their theory examinations where rather mainly theoretical knowledge is as-

[2]The lack of effectiveness here particularly refers to an insufficient focus of curriculum on qualification requirements

sessed. What is even more frustrating is the fact that some students learn primarily those subjects that are assessed in the examination conducted by BTEB[3]. That means when a student is in the 5^{th} semester he or she pre-learns a subject scheduled for the 6^{th} semester.[4] This tendency of passing the examination greatly hampers students in achieving, among others, vocational skills.

1.3. Research Objectives

Polytechnic graduates have traditionally found jobs in the public sector (Ritzen & Balderston, 1975). Increasingly, they will need to look for work in the private sector. The ongoing and predicted changes, particularly, in the private sector, such as new product and process technologies, shortening product life cycles, changing production concepts and strategies of rationalization, global competitiveness, have put new and strong demands on the occupational competence and qualification of the workforce.

In order to meet today's qualification requirements of the national and international job markets the TVET curricula should be responsive, effective and realistic. Therefore, the objectives of this research work are:

- to evaluate the current TVET curricula, particularly the *Diploma-in-Engineering (Electronics Technology)* curriculum, in order to find out how far it meets the qualification requirements of the job market; and
- to compare the competency of Bangladeshi Polytechnic graduates on international level that should help polytechnic graduates to secure jobs or to (further) study abroad.

The more specific objectives are:

- to measure the competency level of the polytechnic students in Bangladesh, particularly in practical related tasks, and to compare it with vocational school trainees in Germany;
- to find out teachers' capability of estimating their students' performance;
- to investigate if there are performance differences among technical institutes;

[3]BTEB conducts examinations of even semesters, i.e. 2^{nd}, 4^{th}, 6^{tt}, and 8^{th}, only; The examinations of odd semesters, i.e. 1^{st}, 3^{rd} and 5^{th}, are conducted by each polytechnic locally.

[4]These findings were gathered by author himself in informal interviews with teachers.

- to assess the examination questions of the *Diploma-in-Engineering* courses; and, finally,
- to provide information about the current curriculum that would be useful to reform / modernise it, if necessary;

1.4. Research Scope

Considering time and labour it would be unrealistic to investigate the curricula for the whole range of occupations. This research work is, therefore, limited to the occupation of *Diploma-in-Engineering (Electronics Technology)* in Bangladesh. However, in order to compare this qualification at international level the vocational school curricula for similar occupation(s) in Germany, as the control group, will be studied. Reviewing the German vocational education and training (VET) curricula, it has been found that no single German occupation profile exactly fits with the Bangladeshi *Diploma-in-Engineering (Electronics Technology)*. However, Germany's two occupations namely: *Electronics Technician for Devices and Systems* and *Electronics Technician for Industrial Engineering* best match with the Bangladeshi *Diploma-in-Engineering (Electronics Technology)*. The study will mainly focus on the assessment of students' competency (the dependent variable) in the above mentioned occupations.

The German qualification for these occupations corresponds to International Standard Classification of Education (ISCED) level 3B. This qualification has not yet been aligned to German Qualifications Framework (DQF). The proposed (draft) version of the German Qualifications Framework is given in Appendix D.2. The qualification for the *Diploma-in-Engineering (Electronics Technology)* is aligned at level 6 of Bangladesh National Technical & Vocational Qualifications Framework (NTVQF) (draft). (More about these two groups (Bangladeshi and German) are given in Section 5.1.)

The selection of this particular occupation has been made on the following basis: *firstly*, the technological standards and qualification requirements in this field on national and global job markets are almost the same; *secondly*, a good number of multi-national and national industries and enterprises, who employ graduates in this field, are now situated in Bangladesh; and *thirdly*, author's biographical background.

1.5. The Research Questions and Hypotheses

1.5.1. The Research Questions

The background and the problems illustrated above lead to the following specified research questions:

Is the focus of Bangladeshi *Diploma-in-Engineering* curriculum more on practical / workplace relevant skills and knowledge, or on theoretical knowledge?
Are the competences acquired by Bangladeshi polytechnic graduates comparable to those of a developed country, for example Germany? More specifically, how good are Bangladeshi polytechnic students at different cognitive levels (reproduction through transfer) compared to Germany?
What makes Bangladesh different from Germany particularly in student assessment approaches?
Are teachers able to judge their students without taking a test?
Do the student performances differ among schools / classes?

In order to find the answer to the above questions this research work examines the *Diploma-in-Engineering (Electronic Technology)* programme in Bangladesh and compares it with Germany. The investigation is, therefore, led by the hypotheses given in the following section.

1.5.2. The Hypotheses

The following is a list of the hypotheses which will be tested in this research work. These hypotheses will be explained together with relevant theoretical backgrounds and test methods in Section 3.2.

The Competency Level of Polytechnic Graduates in Bangladesh

Hypothesis H1: *The competency level, in the case of application-oriented tasks, achieved by the polytechnic students/graduates in Bangladesh at the end of the Four-Year Diploma-in-Engineering course, is lower than that of the vocational school (Berufsschule) trainees in Germany at the end of the Three-and-One-Half-Year Apprenticeship Training in the Dual System.*

Student Performance at Different Cognitive Levels

Hypothesis H2: *The tasks, which require only knowledge reproduction, are solved correctly with a higher probability than the tasks, which require higher level cognitive processes.*

A Comparison of Student Performance: at Different Cognitive Levels in Bangladesh and Germany

Hypothesis H3: *In answering the tasks that demand mainly higher level cognitive processes, the performance level differs notably between the polytechnic students in Bangladesh and vocational school trainees in Germany.*

Teachers' Capability of Estimating their Students' Performance

Hypothesis H4: *The teachers are in a position to estimate the ability of the students to solve the tasks they are set.*

Comparison of Inter School/ Class Performance

Hypothesis H5: *The student performance between schools/ classes differs significantly.*

Student Assessment Approach in Bangladesh and Germany

Hypothesis H6: *The student assessment approaches in Bangladesh and Germany differ greatly regarding their theoretical requirements and practical relevance.*

1.6. Research Methodologies

Data will be analyzed combining both quantitative and qualitative methodologies, however, qualitative and descriptive methods were used only where needed.

The major steps followed to carry out this research are:

1. Review and study of the basics relevant to the research topic;
2. Investigation of the literature and the curricula of Bangladesh and of Germany;
3. Creating the research concept;
4. Analyzing the curricula and examination papers that are used for student assessment;
5. Gathering and compiling qualification requirements for local and global job markets from different sources, for example, job-bank via the Internet, job fairs, trade fairs, et cetera;
6. Collecting the required data through a self-designed questionnaire and a test and consultation with experts, senior teachers, key persons and some students in Germany and Bangladesh;

1.7. Organisation of this Dissertation

This dissertation will be organized into eight chapters. Chapter one presents the research background, the problem, the research scope, the research questions and hypotheses and the methodologies used for this research. Chapter two will provide the definition of research relevant key terms, review the former relevant research work in this field. Furthermore, it will present the TVET systems of Bangladesh and Germany. Chapter three will present the research questions and hypotheses together with relevant backgrounds. Chapter four will describe the occupational profiles in the field of electrical and electronic technology and information and communication technology. An analysis of the curriculum content of the relevant occupations will also be presented here. Chapter five will present the measurement of student's learning achievement (the competency test). It will include the description of both student groups – Bangladeshi polytechnic students and German vocational school trainees. It will also include the construction of the test instrument and its validity and reliability analysis. The support and problems associated during the test running phase will also be given briefly in this chapter. The results of the competency test along with the discussion and the verification of the hypotheses will be presented in Chapter six. Chapter seven will discuss the strength and weakness of the present curriculum and propose a reform (as suggestions and recommendations) in order to enhance the effectiveness of the curriculum. Finally, chapter eight will draw a conclusion with results of verification of hypotheses and a discussion of the research results and future works.

2. Theoretical Basis

2.1. The Technical and Vocational Education Curriculum

This section includes: the curriculum definition, features in the technical and vocational education and training (TVET) curriculum, a brief description of the TVET curriculum development methodologies and the curriculum assessment.

2.1.1. Definition of Curriculum

Curriculum is a training design or plan that defines (D'Hainaut 1981):

- aims, goals and objectives of an educational activity;
- ways, means and activities used to achieve the aims; and
- methods and instruments needed to evaluate actions.

Wilson (1990) states that the word "curriculum" as it is defined from its early Latin origins means literally "to run a course". She describes the curriculum as: "if one thinks of a marathon with mile and direction markers, signposts, water stations, and officials and coaches along the route, this beginning definition is a metaphor for what the curriculum has become in the education of our children."
She describes that a curriculum is:

"Anything and everything that teaches a lesson, planned or otherwise. Humans are born learning, thus the learned curriculum actually encompasses a combination of all of the below – the hidden, null, written, political and societal etc.. Since students learn all the time through exposure and modeled behaviors, this means that they learn important social and emotional lessons from everyone who inhabits a school – from the janitorial staff, the secretary, the cafeteria workers, their peers, as well as from the deportment, conduct and attitudes expressed and modeled

by their teachers. Many educators are unaware of the strong lessons imparted to youth by these everyday contacts."

Atherton (2009) states that the term "curriculum" is used in a number of related ways:

- First, it can refer to the overall content of what is to be taught.
- Second, it can refer to the underlying principles of the approach to teaching and learning.
- Third, it can embrace both elements, and refer to the overall "what", "how" and "why" of teaching.

Finch & Crunkilton (1999, p. 11) define curriculum as
"the sum of the learning activities and experiences that a student has under the auspices or direction of the school".

In this definition there are two supporting concepts. First, the central focus of the curriculum is the student. This means each student has his or her own curriculum, since students often select courses, experiences and noncredit activities that align with their unique personal needs and aspirations. The second is the breadth of learning experiences and activities associated with a curriculum. Formal courses are not the only items considered to be a part of the curriculum. Clubs, sports, and other curricular activities are significant contributors to the overall development of an individual and to curriculum effectiveness.

Curriculum development can be defined as *"the process of defining, organizing, combining, and co-ordinating content so that it leads learners to the acquisition of knowledge, skills, and attitude (KSA)"*(Dunbar, 2002, p. 31). It is "what" the student will learn, not "how" the learning will be accomplished. The latter is instructional design and delivery process (ibid.).

2.1.2. Curriculum vs. Syllabus

The terms “curriculum” and syllabus” are widely used and mean different things to British and American writers and are thus potentially confusing. In White’s (1988) British usage, “syllabus” refers to the content or subject matter of an individual subject, whereas “curriculum” refers to the totality of content to be taught and aims to be realized within one school or educational system”. Thus, a curriculum subsumes a syllabus.

Curricular guidelines lay out a program’s educational philosophy, specify purposes and course content, identify implementational constraints and articulate assessment and evaluation criteria. They also include banks of materials that teachers can modify to meet the needs of their learners. Syllabuses, on the other hand, traditionally represent the content of an individual course and specify how this content is graded and sequenced. According to this traditional understanding of what a syllabus is, therefore, there is a further distinction between syllabus content and methodology, on the grounds that the “what” and the “how” of teaching should be kept distinct from each other (ibid).

2.1.3. Forms of Curriculum

Atherton (2009) sets up a model (Figure 2.1), which works along two dimensions, and distinguishes four types of curricula: academic, vocational/ professional, mastery/ induction, and developmental/ constructive. He derives these types dictated by the questions, “What is this material being taught for?” and (the student version) “Why do we have to learn this?”.

Academic[1]

The curriculum for history or literature, for example, may be considered under this type. The objectives and usage of this type of curriculum are often very general. Comparing this type of curriculum with vocational and professional studies Atherton (2009)

---

[1]Excluding professional university education such as engineering, medicine and other professional studies

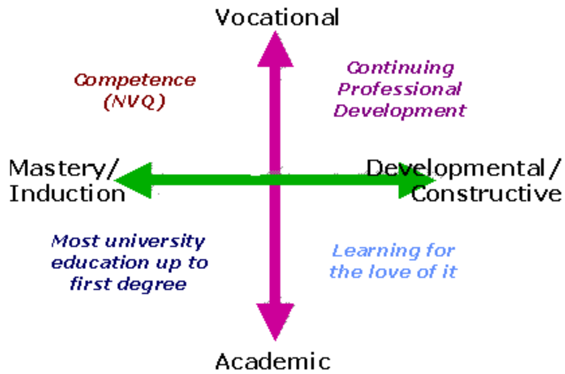


Figure 2.1.: Different types of curriculum. Source: Atherton 2009.

comments that "While academic study is often more highly valued than vocational and professional study, in practice it is often more concerned with the lower reaches of Bloom's taxonomy in the cognitive domain (which may of course be a critical comment on Bloom's construction of *Application* as the third level). The distinctive contribution of the academic curriculum, however, is to the more complex affective domain".

Vocational/ Professional

(Instrumental)

This type of curriculum is developed on the basis of the question "Why does someone have to learn this?" and of the answer "Because he or she can use it for ..." The emphasis is on using the material in order to do something else. The learning objective is not remembering or reproducing when assessed, (for example, how to derive the equation for Ohm's law,) but when to use it.

Mastery/ Induction

This kind of curriculum assumes that what needs to be learned exists "out there" that the task of education (or training) is to induct learners into an established body of knowledge. It has been argued that this is true of most academic knowledge up to first-degree level, and it is necessary to provide a basic foundation. Competence-based curricula are almost necessarily based on this model. It is assumed that the curriculum designer knows what competence consists of, in a particular vocational area, and what performance criteria constitute evidence of it.

Developmental/ Constructive

The other kind of curriculum often concerned with quite advanced skills (rather than simple knowledge) is a developmental one. It is centred on the development of the student and tries to take them forwards from wherever they are to a more sophisticated understanding or skill in a particular area: the measure is ”improvement” rather than the achievement of a particular level.

The above described types of curricula are all “ideal types” in the real world most teaching and learning contains mixtures.

2.1.4. The Structure of Curricula

Curricula, vocational and technical or general, have been traditionally structured subjectwise. In order to develop vocational competence in a better way Germany has introduced a new concept of structuring vocational education and training curriculum - the “Learnig field concept”. The following subsections describe these two types of curricula.

2.1.4.1. Subject Based Approach

In the subject based approach the curriculum content is structured in many independent subjects. The content or subject matter of an individual subject is often presented together with aims to be realized within the subject, also called syllabus. A subject includes several interrelated topics. A topic is further divided into sub-topics.

The structure of the Diploma-in-Engineering curriculum in Bangladesh is subject based. It is a behavioural objective type syllabus, where each sub-topic is stated according to Bloom’s (1956) taxonony of educational objectives. Section 4.4 describes the Diploma-in-Engineering curriculum for the occupational field electronic technology.

2.1.4.2. Learning Field Approach

The “Learning field concept” (Lernfeldkonzept) is a concept of structuring the curricula at vocational schools and gives orientation for the didactic organization and planning of lessons. Typical for the Learning field concept is that content of lessons is related to typical professional actions and situations at work. The professional work process is the starting point for the construction of Learning fields (Lernfelder). The central theme of the “Learning field concept” is the development of occupational competences in unity of technical (domain specific) competence, personal competence (social competence, self-competence) and methodological competence. Because “Learning fields” are related to typical work situations, the learning process of trainees follows the logic of professional action, when a skilled worker carries out a professional assignment (1. look for information, 2. plan, 3. decide, 4. realize, 5. control, and 6. assessment). (Bräuer et al., 2007, p. 161).

The curriculum has been based on a knowledge hierarchy of basic science, followed by applied science and then the technical skills of day to day practice (Enkenberg, 1994). Enkenberg (1994) stresses the importance of learning as being ‘situated’ - knowledge cannot be separated from its source and context or environment.

A “Learning field” is described in the curriculum as a thematic unity with a competence oriented formulation of objectives, contents and time allowed. For the educational process at school a teacher has to define or select several “Learning situations” within a particular occupation. So within of the “Learning field concept”, three connected terms are found: 1. Professional action fields (Handlungsfelder), 2. Learning fields (Lernfelder) and 3. Learning situations (Lernsituationen). Bader (2003, p. 213) shows the connection between these terms as given in Figure 2.2.

In Germany the new curricula for vocational education are developed according to the “Learning field” approach. For each profession there are 12 – 15 “Learning fields” (Bräuer et al., 2007, p. 161). These are big unities with 40 to 80 lesson-hours for each learning field. Learning fields for the occupation “Electronic Technician (Device and Systems)” are given in Section 4.5.

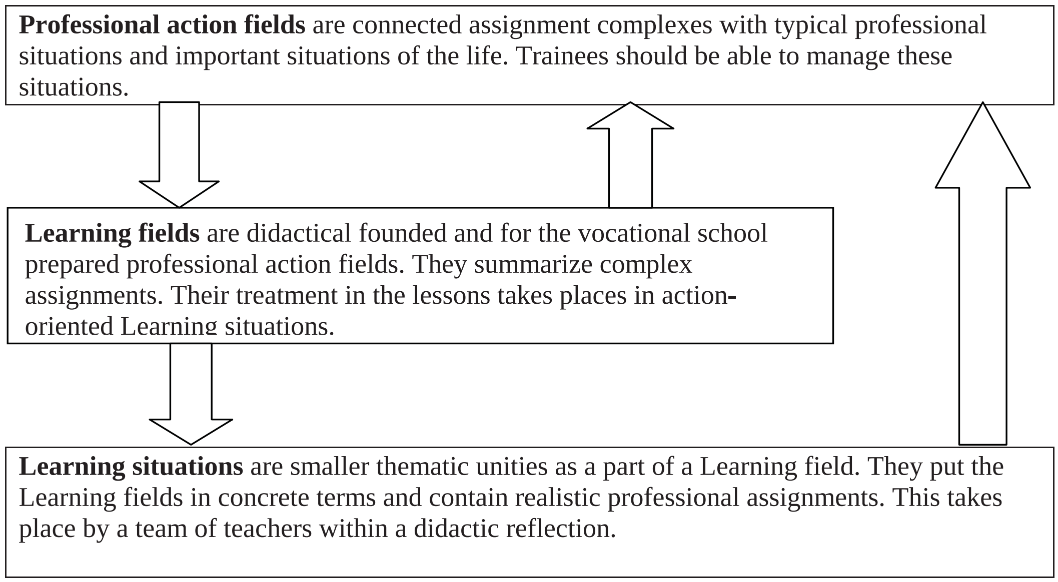


Figure 2.2.: Connection between Professional action fields, Learning fields and Learning situations (Source: Bader 2003)

2.1.5. A Rationale for Curriculum Development in Technical and Vocational Education

A systematically developed technical and vocational curriculum is data-based, dynamic, explicit in its outcomes, fully articulated, realistic, student-oriented, evaluation-concious, future-oriented, and world class-focused (Finch & Crunkilton, 1999, p. 19).

Data-based. A technical and vocational curriculum needs to be founded upon appropriate school- and community-related data.

Dynamic. A technical and vocational curriculum must be constantly examined in terms of what it is doing and how well it meets student needs. It should be reviewed regularly to make it responsive to changes in the world of work.

Explicit. Curricular outcomes must be defined as explicitly (clear and precise) as possible. It helps to measure whether students achieve the outcomes related to a particular occupation or field.

Fully articulated. This includes arrangements of subjects (or learning fields) and other educational activities that contribute to the quality of a curriculum, resolution of content conflicts accross different areas, development of a logical instructional flow from one year to the next. It also includes, for example, deciding which mathematics concepts should be taught as a prerequisite and/ or within a particular technical course. It may include the articulation of curriculum content among technical vocational and general and higher education courses.

Realistic. A TVET curriculum should be consistent with the needs of the labour market and relevant to current and future job opportunities, if students are to be prepared properly for employment.

Student-oriented. A TVET curriculum should meet students' needs. It should allow various learning-teaching methods/ approaches.

Evaluation-concious. Plans must be made to evaluate the effects on students while a curriculum is designed. Curriculum evaluation reveals its strenghts and weakness to the concern authorities.

Future-oriented. Any curriculum which should be relevant tomorrow must be responsive to tomorrow's needs as well as today's needs.

World class-focused. The performance of TVET graduates should result products and services that should be world class standard.

2.1.6. Establishing Curriculum Content

According to Rauner (1986) a curriculum should include, from an anthropological perspective, the technology (the construction and functionalities of components and systems), the usage of technology, as well as the historical development and the effect of technologies on society and ecology (cf. Nickolaus 2008, p. 67ff.). In a newer work Rauner includes the importance of implicit or explicit learning at the workplace (ibid. p. 69; with reference to Rauner 1996, p. 424). Finch & Crunkilton (1999, p. 12) states that "a curriculum should focus on developing the whole person". Therefore, the TVET curriculum should include technical and vocational courses and experiences and also general courses (e.g. mathematics, physics, environmental science, languages, etc.).

General studies serve to provide the student with a broad knowledge base both for life and for earning a living (ibid.).

Hence, in the process of establishing meaningful content, initially it is important to determine the range of content that has potential to be included in a curriculum. After potential content has been identified, decision is to be made regarding which content may be used in a particular educational setting. In the determination of curriculum content, it becomes vitally important to ensure that its content reflects the needs of the world of work (Finch & Crunkilton, 1999, p. 127). Consideration must be given to future as well as current employer needs (ibid. p 133).

A set of studies presented by Bailey (1990) supports the changing nature of the workplace. It strongly supports the notion that jobs of the future (both in the service and manufacturing areas) will require greater and not fewer skills. Curriculum developers must recognise that future jobs will require workers to display a broader range of skills and to demonstrate them at higher levels. Employees must be able to change and develop as an industry or business evolves.

In determining the curriculum content, it is also considered that there is an essential overlapping area between the professional knowledge of university graduates, who require (high profile) professional knowledge, and professional knowledge of technicians/ skilled workers (cf. Nickolaus 2008, p. 58; with reference to Grüner 1978, p. 78).

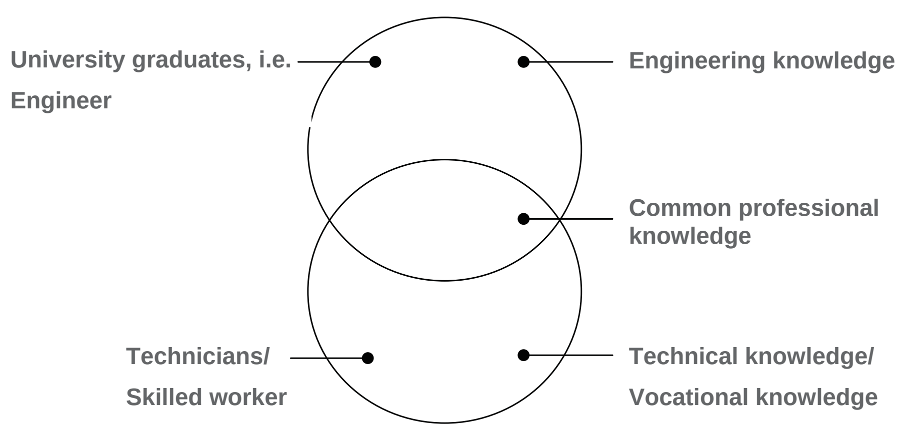


Figure 2.3.: A model representation showing the relation between scientific/ engineering and technical/ vocational type knowledge. (Grüner, 1978, p. 79).

The common (overlapping area, Figure 2.3) knowledge is subdivided into two areas by Grüner:

1. Knowledge which is shared by both groups of professionals (for example, DIN Rules and Regulations, IEC standards);

2. Technical knowledge which is to be delivered to the technicians/ skilled workers in a simplified form (for example, function of an electrical machine) (ibid. p.79).

For the simplification of the knowledge form described in the second item (2.) didactic reduction methodologies, e.g. the didactic reduction according to Hering (1998) and Grüner (1978), can be applied (Nickolaus, 2006, p. 59). Additionally, the curriculum content must be accompanied with aims and objectives.

The various strategies used to determine curriculum content (the technical content) usually include: the philosophical basis, introspection, DACUM approach, job analysis, et cetera. Below there is a short description of DACUM, since it is widely used in determining the technical and vocational curriculum content.

DACUM Approach to Curriculum Content Determination

DACUM (Developing a Curriculum) is an occupational analysis method (DACUM, 1995). In determining curriculum content it uses the technique of team work, with teams formed by experts employed in the occupational area. This method allows the experts to be guided through a systematic content determination process. For example, to make a workshop that uses DACUM groups of five to twelve people are formed. They are guided by a facilitator and are supposed to describe in a clear and precise way the knowledge and the "know how" involved in the job position.

The result of the occupational analysis is usually expressed in the so-called "DACUM letter" or "DACUM profile" where the job position is described in terms of the competencies and sub-competencies it requires. Here the term "competency" means the description of big tasks and, at the same time, it is the sum of a number of small tasks called sub-competencies. The total amount of competencies makes up the description of the tasks involved in a certain job position. The DACUM letter also includes the necessary knowledge, behaviours, directions/guidelines, equipment, tools, materials and the future development of a job position, as optional.

Once the DACUM profile has been developed, the product may serve as a basis for developing instructional content and materials that focus on student attainment of specified skills. Technical/ vocational instructors are involved, usually after the (draft) profile has been produced. They are recognised for their overall technical expertise and ability to organise, sequence, detail curriculum content (Finch & Crunkilton, 1999, p. 1143).

More recently the DACUM approach has been expanded in scope to encompass course and programme development.This is accomplished by using a development process called Systematic Curriculum and Instructional Development (SCID). DACUM is used in the analysis phase which is the first of five SCID phases. The other four phases include design, instructional development, training implementation, and programme evaluation (Stammen, 1997).

Basic principles of DACUM:

- **Expert workers can describe their job better than anyone else.** Those workers whose occupation is the object of the analysis and who have a good performance in that position are real experts on that type of job. Although first-rate supervisors and managers may know a lot about the work developed, they usually lack the necessary level of expertise to conduct a good analysis of such job.
- **An effective way of defining an occupation is describing the tasks developed by expert workers.** A worker may carry out several tasks that are highly appreciated by their colleagues and internal clients. To do this, attitudes and knowledge alone are not enough; they do things the right way when they develop activities which, if known by the enterprise, may facilitate better training for everyone else.
- **To develop all tasks in an appropriate way, knowledge, behaviour and skills need to be applied, together with the use of tools and equipment.** DACUM gives importance to the detection of factors that explain a successful performance. Therefore, it seeks to establish not only tasks but also a list of such factors. It

further specifies the tools with which the worker interacts in order to facilitate practical training.

2.1.7. Evaluation of Technical and Vocational Education Curricula

The evaluation of a curriculum can help to ensure that the curriculum is of a high quality and that the deficiencies are identified before they cause major problems. Because a curriculum has so many components, evaluating an entire curriculum is quite complex, time consuming and costly (Kenneke 1995 p. 5; Finch & Crunkilton (1999)). Thus, an evaluation often tends to focus on *programmes* and *materials*. The techniques used to evaluate curricula tend to be categorised as being either quantitative or naturalistic. Quantitative techniques focus on specific outcomes, criteria, and objective measures. Naturalistic techniques, on the other hand, place less emphasis on outcomes and more emphasis on process (Finch & Crunkilton, 1999, p. 272).

Since the contemporary curriculum is quite comprehensive, evaluation must also be comprehensive, taking into account the various aspects of curriculum planning, development, operation, and refinement (ibid, p. 273). The diagram presented in Figure 2.4 portrays an evaluation scheme that is both comprehensive and systematic. The four elements of evaluation include:

- *Context,* which deals with whether or not to offer a curriculum and, if so, what its parameters will be including focus, goals, and objectives.
- *Input,* which relates to deciding what resources and strategies will be used to achieve curriculum goals and objectives.
- *Process,* which focuses on determining what effect the curriculum has on students.
- *Product,* which deals with examining the curriculum's effects on former students.

Context, input, process, and product (CIPP) have been espoused by Stufflebeam and others [Stufflebeam at al., 1971; Webster, 1981; Armstrong, 1989] as the key elements of a comprehensive evaluation, particularly when information is gathered and used for decision making. Context and input evaluation focus on gathering information and

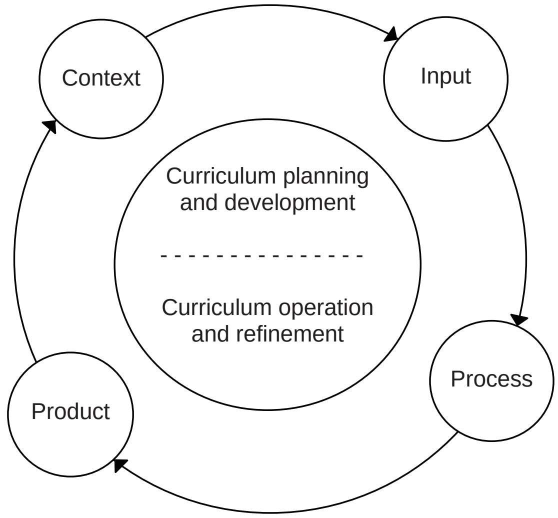


Figure 2.4.: A framework for curriculum evaluation. (Finch & Crunkilton, 1999)

making decisions relative to curriculum planning, curriculum development, and curriculum materials's development. Process and product evaluation relate to curriculum operation and refinement.

The competency test conducted under this research project is an evaluation that is partly context evaluation and partly process evaluation. In context evaluation, since the curriculum for Diploma-in-Engineering (Electronics Technology) is already offered, information will be gathered on current knowledge and skills requirements of jobs in this area. Here in process evaluation it will be examined, among other things, to determine the extent to which students have achieved certain curriculum objectives.

2.2. The Meanings of Occupational Competence and Qualification

2.2.1. The Concept of Occupational Competence and Qualification

In literature the concepts of competence and qualification are often poorly defined. A general consensus seems to be lacking concerning the meaning of these concepts.

According to one view competence is considered as an attribute of the employee, that is, as a kind of human capital or a human resource that can be translated into productivity. For example, in Humphrey's (1992, p 61) definition, "a competence is the ability of the learner to put skills and knowledge into action." According to another main view, competence is defined in terms of the requirements of a certain class of work tasks (a job) (Ellström, 1997, p. 267). This is indeed an important distinction, and in the following (also in this work, in general) the term competence will be used to refer to the former meaning, and the term qualification[2] to refer to the latter meaning.

Hence, the term competence is the potential capacity of an individual (or a collective) to successfully[3] handle certain situations or complete a certain task or job (Ellström, 1994). This capacity may be defined in terms of (cf. Ellström, 1997 p. 267):

- perceptual motor skills (e.g. dexterity);
- cognitive factors (different types of knowledge and intellectual skills);
- affective factors (e.g. attitudes, values, motivations);
- personality traits (e.g. self-confidence);
- social skills (e.g. communicative and cooperative skills).

Thus, according to this definition, *occupational competence* refers to (ibid.):

- a relation between the capacity of an individual (or a collective) and the requirements of a certain (class of) situation(s) or task(s);
- knowledge and intellectual skills (e.g. inductive-logical ability), but also, contrary to more restricted definitions, non-cognitive factors (e.g. motivation, self confidence);
- a capacity that is a complex function of the five classes of components listed above;
- a potential rather than an actual capacity, i.e. a capacity that is actually used if and only if certain conditions are present (e.g. a challenging task or a work organization with a certain autonomy).

[2]The term *Qualification* also describes a formal outcome of an assessment and validation process which is obtained when a competent body determines that an individual has achieved learning outcomes to given standards (German Qualifications Framework, 2009).

[3]according to certain formal or informal criteria, set by oneself or by somebody else

Using this definition as a point of departure, the notion of qualification may now be defined as the competence that is (ibid):

- actually required by the work task; and / or
- implicitly or explicitly prescribed by the employer.

As implied by this distinction the individual (or the work force) may possess a range of competences that are not qualifications, that is, that are not required by the work or prescribed by the employer. Conversely, the work may require qualifications that do not correspond to the actual competences of the individual (or the work force). Thus, the concept of qualification focuses on competences that, for one reason or another, are valued on an internal or external labour market, that is, competences that have an exchange value (cf. Ellström, 1997 p. 267).

The changing concept of occupational competence

The concept of competence has been experiencing a process of continual change. Traditional definitions and explanations of occupational competence or expertise have been based on theories of technical rationality, on the basis that learning can be applied in predictable and repeated ways (Edwards, 1993). Up untill the 1960s occupational competence could be replaced with one-dimensional "technical expertise". The focus was "only" on imparting knowledge and skills [cf. Knöll 2007, p. 12; Ott 1995, p. 50; also §6 and §9 German Vocational Training Act (BBiG)], so that the trainee should be able to follow instructions carefully and perform the functions. Vocational training is therefore "still oriented to technicians with the principles of repetitive tayloring-work, performing work as directed" [cf. Knöll, 2007, p. 12; Czycholl & Ebner, 1995, p. 43; Straka, 2001]. Since the 80s of last century, due to the changing qualification requirements of the workplace, the meaning of occupational competence has undergone major modifications (Figure 2.5).

The changes in types of work and in qualification requirements are largely motivated by the ever-increasing and profound applications of (micro-) electronic systems in operations and manufacturing processes, increasing automation and rationalization (cf. Knöll 2007, p. 12; the Senate Commission for Vocational Education Research of the

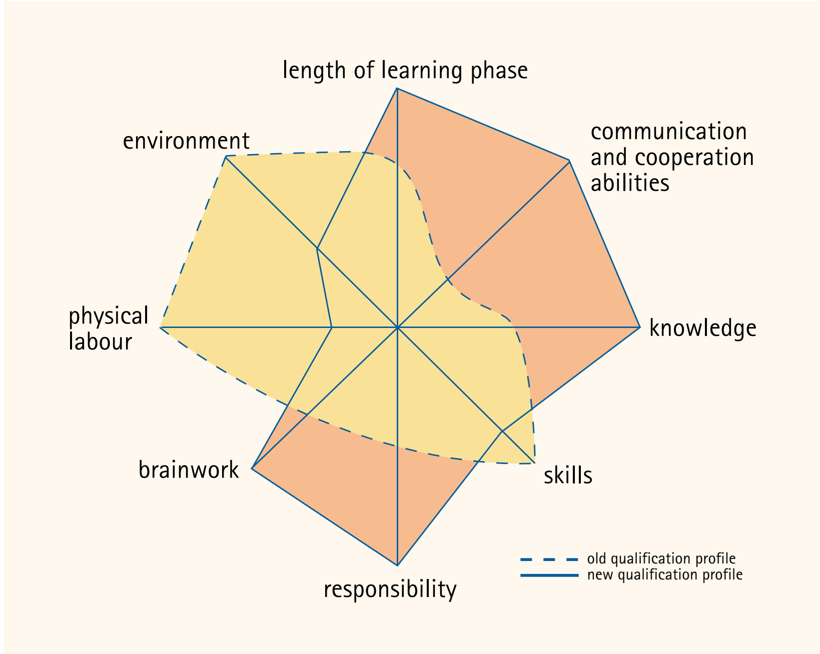


Figure 2.5.: Competency undergoing continual change. (Tippelt & Amorós, 2003)

German Research Foundation (DFG) (memorandum) 1990, p. 45). References are often made to the following: the new information and communication technologies; the modified work organization concepts, such as the move away from a Taylorist mode of production; introduction of team work; increasing levels of responsibility, among others; the rapid obsolescence of knowledge and the increasing change of qualification requirements for workplace [cf. Knöll, 2007, p. 12; with reference to Frackmann, 2001, p. 217 and Mertens, 1974, p. 39)].

On the basis of the above facts, the following changes in the field of production have been predicted [cf. Knöll 2007, p. 13; Senate Commission for Vocational Education Research of the DFG (memorandum) 1990, p. 46]:

- Reduction of manual functions, such as manual labour and manual transport;
- Reduction of manual and visual control work;
- Increase of controlling and monitoring functions in the production process;
- Extension of planning, production preparation tasks;
- Increase of maintenance and repair services.

These observations imply that future qualification requirements will demand higher intellectual skills on the part of workers employed in the manufacturing sector (ibid, p. 46). According to Reinberg (1999, p. 434), this trend, just sketched above, will continue towards more demanding activities and higher qualifications. In particular, an extension of the qualification requirements for social and communicative skills and for the capacity of self-organisation is recommended, both for the unskilled and the semi-professionals (Baethge & Baethge-Kinsky 1995, p. 154). In addition, the professional competencies is to be accompanied by the inclusion of commercial, financial and organizational skills (cf. Knöll 2007, p. 14; Kurz 2002, p. 610) and possibly the command of the English language.

Occupational competence is understood by KMK (2007, p. 10) in Germany as the willingness and ability of individuals to behave in an appropriate and well-reasoned, individually and socially responsible manner in professional, social and personal situations.

According to KMK, the Bader / Müller's competence model, the occupational competence unfolds to the dimensions of professional (domain specific) competence (Fachkompetenz), self-competence (Selbst- / Humankompetenz) and social competence (Sozialkompetenz). These dimensions are seen not as isolated, but mutually connected factors (Figure 2.6).

Professional competence[4], denotes the willingness and ability to solve tasks and problems in a goal-oriented, well-reasoned, methodological, and independent manner and to assess the outcome on the basis of professional knowledge and skills [KMK, 2007, p. 11; DQR, 2009, p.15].

Self-competence denotes the willingness and ability as an individual personality to clarify, reason, and evaluate the development opportunities, requirements and limitations in family, work and public life, to develop his / her own talents and to grab and to further develop his / her life plans. It includes features such as self-reliance, ability to criticise, self-confidence, reliability, responsibility and sense of duty. It also includes in particular the development of well thought-out values and the self-commitment to values (ibid.).

[4]This is *Domain specific competence*. In the field of TVET, more specifically, it is *Technical competence*

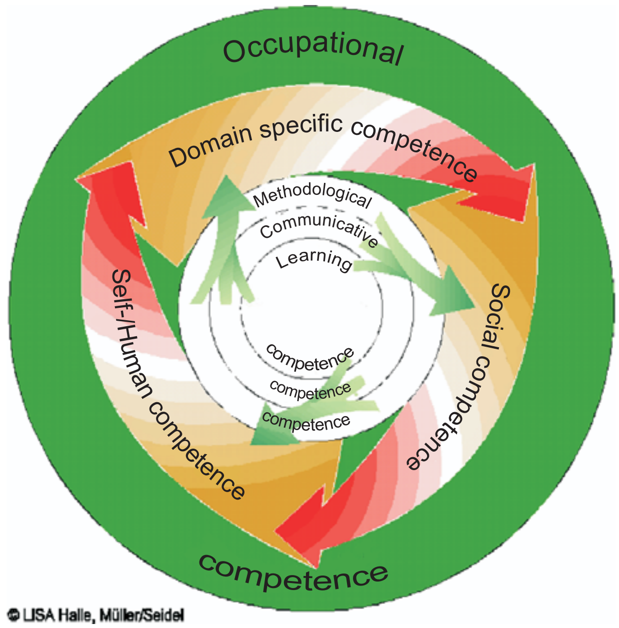


Figure 2.6.: Dimensions of occupational competence and their relationship according to Bader (2004, p. 22).

Social competence describes a persons ability and readiness to work together with others in a target oriented manner, understand the interests and social situations of others, deal with and communicate with others in a rational and responsible way and be involved in shaping the world of work and the lifeworld. This particularly includes also the development of social responsibility and solidarity (ibid.).

Integral parts of the above mentioned dimensions (professional competence, self-competence, and social competence) are methodological competence, communicative competence and learning competence. So, for example, Methodological competence is not an independent dimension of occupational competence, but only a particularly strong accentuation (besonders prägnante Akzentuierung) of occupational competence.

Thus, the competency model, that underlies the learning field concept, can be seen as a matrix of vertically and horizontally interrelated competences (Table 2.1) (Hensge et al., 2008, p. 11).

Methodological competence describes the ability to be guided by rules when acting. This may also include the considered selection and development of methods and strategies. Professional competence and personal competence (self-competence and social competence) each incorporate methodological competence (Figure 2.6).

Table 2.1.: Competence model in matrix form according to Bader & Müller

	Professional competence	Self-/Human competence	Social competence
Methodological competence			
Learn competence			
Communicative competence			

Communicative competence is the willingness and ability to understand and to participate in communicative situations. This includes perceiving, understanding and presenting his or her own intentions and needs and those of the partners (ibid.).

Learning competence, or learning to learn, is the ability to pursue and organise one's own learning, either individually or in groups, in accordance with one's own needs, and the awareness of methods and opportunities (ibid).

In summary, a wide range of additional competences was / will be demanded from the workforce, therefore the term occupational competence will continue to unfold[5].

2.2.2. Different Views and Meanings of Occupational Competence

Ellström (1997, p 267) illustrates three views and five meanings of occupational competence (Figure 2.7).

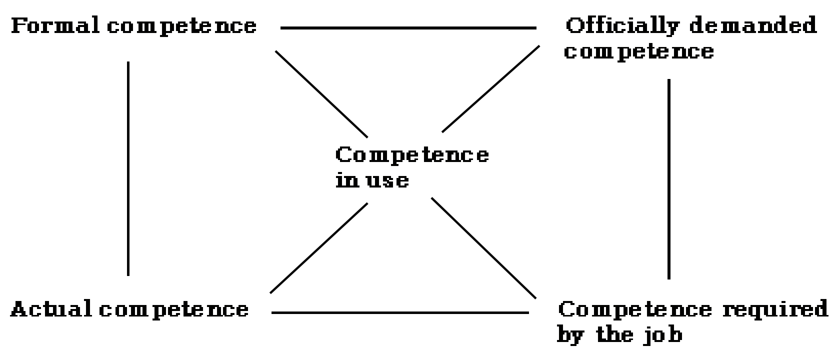


Figure 2.7.: Different meanings of occupational competence

[5]The newly adopted BerBiRefG (German VET Reform Act, enactment on 1 April 2005) cited the extended meaning of occupational competence (i.e. §13 and §14; cf. the Federal Ministry for Education and Research 2005). (cf. Knöll 2007, p. 14)

Competence as an attribute of the individual

The first view is the previously mentioned position that competence is an attribute of the individual, that is, a human resource or a human capital that workers bring into their jobs. From this view it is possible to make a distinction between (ibid.):

- formal competence measured, for example, by the years of schooling completed; and
- actual competence, i.e. (as defined above) the potential capacity of an individual to successfully handle a certain situation or to complete a certain task.

This view of competence is similar to that of the human capital theory (Becker, 1975). Traditionally, this approach has focused on formal competence, i.e. the amount of time spent in educational activities, as a measure of actual competence. The criticisms levelled against the human capital approach have argued, among other things, that the use of formal competence as a measure of actual competence ignores the qualitative differences in schooling and the impact of these differences on the formation of actual competence, i.e. human capital (Rumberger, 1994). In fact, the actual competences differ, by definition, from the formal competences. Because the actual competence is the educational outcomes, plus the learning outcomes of work and a wide range of different informal, everyday activities (Ellström 1997, p. 268).

Competences as job requirements

According to this view, occupational competence is defined and analyzed in terms of prescribed or actual job requirements, i.e. in terms of the qualifications required by the job (compare the definition of qualification given above). From this view, a distinction can be made between:

- the official demand for competence (the qualification demand,
  e.g. for recruitment basis or for pay-scale setting); and
- the competence actually required by the job (the qualification requirement).

Ideally, the official demand for competence corresponds to the actual competence requirements of a certain job. However, the official demands for competence may be higher or lower depending on the demand and supply of qualified people in the labour market or professional bodies force to raise or lower the status of a job position or the actual requirements are unknown.

An interactive view: competence-in-use

According to this third view the competence is neither primarily an attribute of the individual worker (or the collective of workers), nor primarily an attribute of the job. It focuses on the interaction between the individual and the job, and on the competence that is actually used by the worker in performing the job.

The notion of competence-in-use is influenced partly by the competence that the worker brings into the job, and partly by the characteristics of the job. Thus, competence-in-use might be seen as a dynamic factor mediating between the potential capacity of the individual and the requirements of the job.

2.2.3. A Discussion of the Qualification Requirements in Today's Workplace

As discussed above, the qualification requirements (the competences) in today's workplace are multidimensional [cf. Hensge et al., 2008, p.13; KMK, 2007; Bader & Müller, 2002; Dilger & Sloane, 2005; Winther & Achtenhagen, 2009]. It is multi-dimensional in the sense of bringing together vocational skills with pedagogical skills. Vocationally organised work is itself becoming multidimensional.

According to Nickolaus (1997) forecasts predict that the share of unskilled and semi-skilled employees will decline (cf. Knöll 2007, p. 14, with reference to Henninges 1996).
Possibilities of participation, regarding innovation activities, are distributed unequally. The direction and the degree of competence change is visible, regarding the operational work structures, different types of activities, departments and hierarchical levels (Knöll 2007, p. 15, with reference to Kurz 2002, p. 602).

Because of the uncertainties in the forecasts of future skill requirements Nickolaus (1997, p. 188) suggests, from an educational perspective, a type of occupational training, which addresses challenging tasks. Alternatives may not be acceptable (Knöll 2007, p. 15, with reference to Nickolaus 1997, p. 188). Otherwise, learners risk too narrow qualification that may create barriers to the access of higher level activities (ibid.).

In summary, the technical and vocational education and training (TVET) should be based on broad occupational fields, rather than narrow occupational competence. It should focus on the acquisition of workplace relevant skills, knowledge and also key competences in order to enhance the transferability of learning and competence both within the occupational family as well as to associated occupational groupings.

2.3. Factors Influencing the Development of Competence

The development of students' competencies is not only dependent on the curriculum but also on various other factors such as the individual learning ability of the students (cognitive, non-cognitive), individual learning activities, process characteristics of teaching and industrial training/ attachment, learning environment, teachers'/ trainers' qualifications, classroom context, types of tasks in industries / laboratories (workplace relevance, complexity, innovation / creation), school context and enterprise context, among other things (Nickolaus, 2008, p. 10). Figure 2.8 shows a framework model for development of occupational competence.

Conditions of systematic learning-teaching processes, which include the curriculum on the meso level, influence directly the learner's perception and the learning process. Teachers and trainers should be aware of these conditions and consider them while designing systematic learning-teaching processes.

Within *learning-teaching processes* teachers / trainers plan and implement learning-teaching arrangements that are coordinated to a greater or lesser extent. The planning refers to the so called decisive factors (Entscheidungsfelder) (objectives, contents, interactions, media, methods, assessment and evaluation systems).

At *the output and outcome stages* of systematic learning-teaching processes the intended results (bases on *Lempert*) are: workplace relevant qualification and competences; work-related social competences and general individual characteristics of a learner. It should be checked, however, through assessment and evaluation systems, how many of these intended results are achieved. (Nickolaus, 2008, p. 8)

2.3.1. Some Findings of Subject Independent Research in Learning-Teaching and Educational Psychology

A summary of the determinants of student performance according to Helmke & Weinert (1997, p. 78) is given in Table 2.2. These determinants of student performance were confirmed through a meta analysis by Fraser et al. (1987) (cf. Nickolaus 2008, p. 97).

It can be seen from the result of the meta analysis (Table 2.2) that the teacher (r = 0.21); the instruction (r = 0.22), the instruction quality (r= 0.47), the quantity (r = 0.38), and the teaching methods (r = 0.17)); the cognitive characteristic of students (r =0.44); learning strategies (r = 0.28), reinforcement model learning (r = 0.49) or remedial learning (r = 0.30); the domestic environment (r = 0.31) as well as the learning environment that includes, among others, the curriculum complexity level[6] (r = 0.26) all play significant roles in developing students' competencies. Since the curriculum complexity level correlates (r = 0.26) with student performance development, an inadequate curriculum (too complex or too simple or not yet properly tuned)

[6] The curriculum content contributes directly to domain specific competences. It also defines the students' cross-occupational and basic (key) competencies.

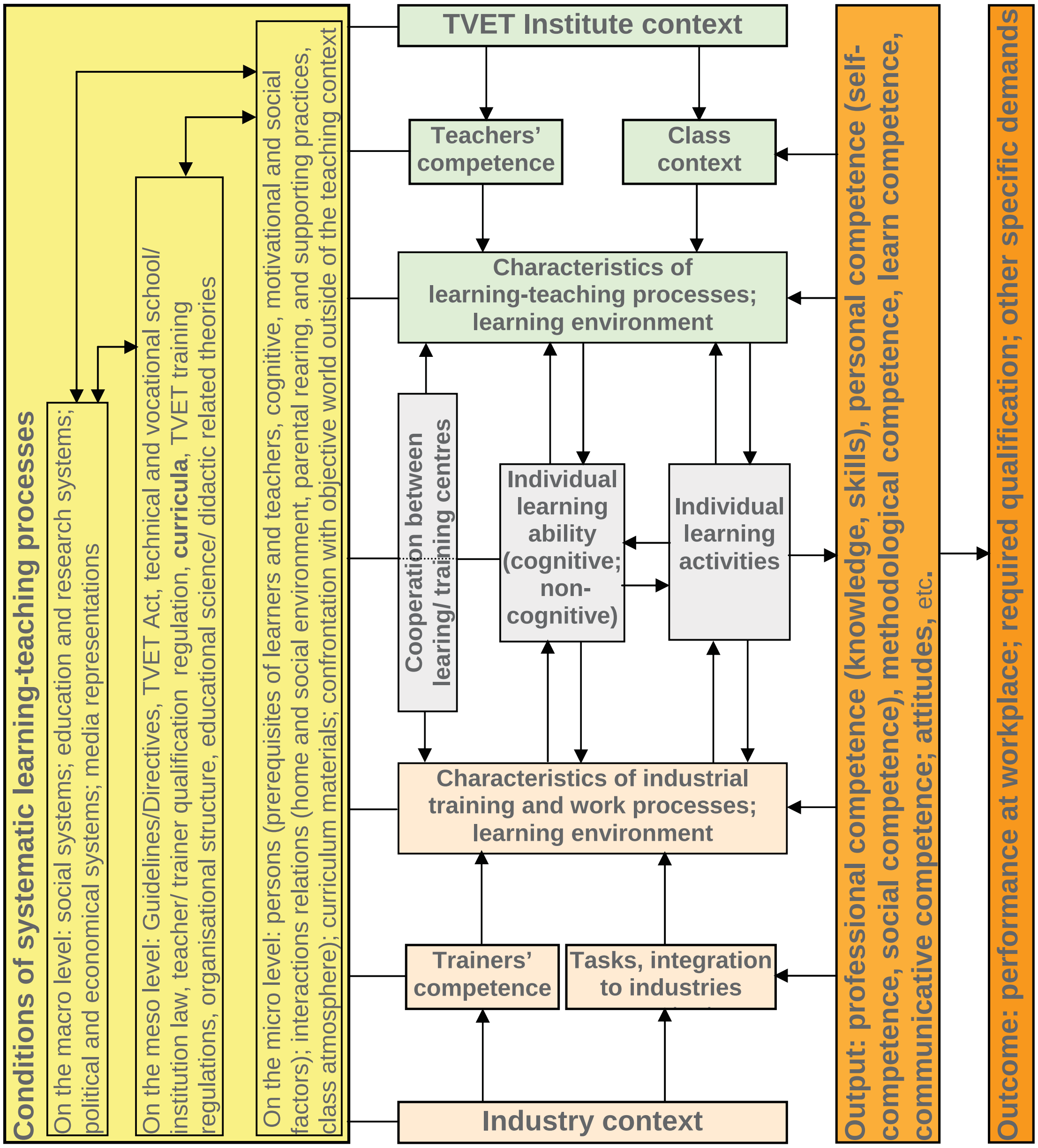


Figure 2.8.: Framework model for the development of occupational competence. (Based on Nickolaus 2008, p. 10; Nickolaus 2010, p. 5)

Table 2.2.: Determinants of student performcance (cf. Knöll (2007), p. 123)

Determinants	Number of studies	Average r
Social contextual conditions	153	0.19
Relationship with peers	12	0.19
Home environment	118	0.31
Consumption of mass media	23	-0.06
School	781	0.12
Aims and policy	307	0.12
Organisation (i.e. class size, traditional or open classroom)	372	-0.02
Learning environment (i.e. cohesiveness in class, curriculum complexity level	102	0.26
Teacher	329	0.21
Instruction	1854	0.22
Quantity	110	0.38
Quality	41	0.47
Instructional method	1763	0.17
Special instruction methods	2541	0.14
Individualisation	467	0.07
Computer support	557	0.15
Tutorial systems	218	0.25
Goal oriented learning	106	0.25
Home tasks	44	0.21
Instruction media	657	0.14
Student characteristics	1455	0.24
Cognitive	484	0.44
Affective	355	0.12
Learning strategies	714	0.28
reinforcement model (bekräftigungslernen)	76	0.49
Remedial learning	97	0.30

may hinder the development of students' competencies.

Regarding the interpretation of findings of the meta analysis by Weinert (1996), it does not allow us to draw any direct practice-relevant conclusions (cf. Knöll, 2007, p. 123). Furthermore the meta-analysis can mask many important specific findings (ibid.). Helmke & Weinert draw attention to the fact that all determinants show relatively small effect strength on an average (Knöll, 2007, cf. p. 124, with reference to Helmke and Weinert, 1997).

However, these findings are supported by relatively new research conducted by Wang et al. (1993) in the United States. On the basis of content analysis, expert ratings, and the evaluation of meta-analysis they compacted 224 variables in altogether 28 categories and then again in 6 theoretical constructs. They summarize the result of this secondary analysis as follows:
"In this research, the theoretical construct with the greatest effect was Student Characteris-

tics, followed by Classroom Practices, and Home and Community Educational Contexts. Less effect was displayed by Design and Delivery of Curriculum and Instruction and School Demographics, Culture, Climate, Policies, and Practices. While State and District Governance and Organization had the least effect" (cf. Knöll, 2007, p. 124).

A differentiated look at the category level shows "Classroom Management[7], Meta cognitive, Cognitive, Home Environment, and Student and Teacher Social Interactions" as the most effective factors (ibid.). The category Curriculum and Instruction can be found at place nineteen of altogether 28 categories (ibid.).

Large-scale studies such as PISA have repeatedly found a close link between educational achievement and family background in Germany [McElvany (2007); Artelt et al. (2005)]. "The family is one of the most important out-of-school contexts for achieving competences." (ibid.). Institutional and individual context factors are fundamental for young adults competence developments (VET-LSA, 2009).

It can be concluded that student performance is determined in a complex manner by individual, school and family condition factors equally. However, it remains unclear how these different determinants interact and / or mutually influence each other [cf. Knöll, 2007, p. 124; with reference to Helmke & Weinert 1997, p. 139].

Intelligence and prior knowledge

Intelligence and prior knowledge are particularly significant determinants for competence development. Research results support that the human brain has an excellent adapting ability. However, the perception differs from person to person, depending on individual learning history and prior knowledge. Learning depends on prior knowledge during solving knowledge-rich problems. Findings on analogical transfer suggest that transfer does not occur automatically for knowledge-rich problems; rather it depends on the ability of the problem solver to recognize potential structural similarities among problems. Recognizing structural similarities is affected by prior knowledge as well as by solution-irrelevant surface features of the problems (Scheiter, 2004).

On the basis of studies of research literature Dochy (1992, p. 24) estimates that contributions of prior knowledge for the variance explanation of success in learning are 30 to 60% (cf. Knöll,

[7]Examples of classroom management techniques included the prompt and efficient handling of routine tasks, the minimization of destructions and interruptions, having materials ready for use, and handling behavior problems in a manner that is minimally disruptive to the classroom." (Wang et al., 1993, p. 277)

2007, p. 128). Also Gagné (1962) within his model conception of cumulative learning refers to the function of the already existing knowledge for the acquisition of new knowledge (ibid.; Helmke, 1997, p. 107). When prior knowledge is referred to as the best single predictor, an implicit assumption is made that the prior knowledge is of good quality, namely that it is "reasonable complete and correct, of reasonable amount, of good accessibility and availability, and well structured" (ibid.). Depending on the quality of prior knowledge individuals can facilitate the learning process, but, for example, with false concepts or bad structuring, learning can also be hindered by it (cf. Knöll, 2007, p. 128).

Motivation and Interest

It has been proved empirically that motivation and interest factors correlate notably with student performance (cf. Knöll, 2007, p. 131). Pekrun & Schiefele (1996) explain that the interest in learning content effects positively, since here a learner applies in-depth and comprehensible learning strategies, for example, organisation and elaboration. On the other hand, he or she applies superficial learning strategies if there is a lack of interest. The interest varies through with the course of schooling time, depending on the learner's interest in subject matters (curriculum content). For example, there can be an increased interest in a particular subject or topic that makes other subjects less interesting. Research results show that learners are not motivated "to learn everything" regardless of the personal importance of learning contents, as an "omnivore" (Schiefele et al., 1993, p. 139); (cf. Knöll, 2007, p. 133).

2.3.2. Some Findings of Learning-Teaching Research in Technical and Vocational Education for the Development of Competence

Despite the fact that TVET is a national priority area for human resources development and poverty reduction in Bangladesh (Section 1.1.3) this sub-sector suffers badly from research deficit. In Europe too there is a lack of research that focuses on technical and vocational education and training, particularly in the area of competence development it lacks the necessary depth that it deserves (Becker & Spöttl, 2008, p. 15). They (Becker & Spöttl, 2008, p. 15) describe the current VET research situation in Germany as: "Eine konsequente Hinwendung zu einer empirischen Berufsbildungs- und Qualifikationsforschung fand in den vergangenen Jahrzenten nicht statt, so dass bis heute vor allem das Wissen über Berufsarbeit und Arbeitsprozesse und deren Zusammenhänge in vielen Gebieten nur unzureichend erschlossen ist. Dies gilt in besondererweise für Erkenntnisse zur Unterstützung der Kompetenzentwicklung für einen Beruf. Deshalb gelingt es kaum, aus einer Perspektive mit deutlichen Arbeitsbezügen Lehrpläne für die berufliche Bildung zu formulieren, die dann auch konsequent in der Berufsbildungspraxis ihre Umsetzung finden."

Nevertheless, some research results in the field of TVET, particularly the effect of teaching methods on the development of competence, are presented below:

In the field of TVET it has basically been assumed that “action-oriented learning-teaching”[8] arrangements may be advantageous for the acquisition of competence, particularly the development of methodical and social competences and the ability to solve problems that may arise in the occupational context (cf. Nickolaus 2009, p. 1; Döring, 2003, p. 66 ff). At the same time, the advantage of this learning-teaching arrangements over the traditional directive learning-teaching method has been assumed for the development of motivation as well as for the avoidance of the acquisition of “inert” knowledge[9] (Nickolaus 2009, p. 1).

However, none of the above assumptions have as yet been empirically confirmed, as is shown in the following summary of some empirical research findings, particularly in the area of electrical & electronic technology, at secondary level (Nickolaus, 2010a, p. 6):

1. In some cases, the findings contradict the assumptions made above. It has been shown that domain specific prior knowledge (fachspezifisches Vorwissen), the key competences[10] (literacy, numeracy) and to a much smaller extent the quality of training at enterprises and schools, are the central influencing factors on the development of competence. For the training in the dual-system, in contrast to the the full-time school system, the “action-oriented learning-teaching” can be proved to have certain advantages, particularly in the case of the domain specific problem solving capability. For weak trainees, however, a support in basic competences, for the development of competence, is more promising than the methodical arrangements of action-oriented learning-teaching.
2. In the area of motivation development in commercial-technical and, particularly, in electrical and electronic technology areas the methodical choice proves to be less important than other factors. In particular, the relevance of curriculum content (attributed by students / trainees) is of great importance [Bieg & Mittag (2009); Geißel (2008)]. But also the other factors such as the experience of competency (Kompetenzerleben), social integration, an appropriate level of requirements (in particular avoiding overburdening), clarity and autonomy have positive correlations with the development of motivation. It can be confirmed partially that the selection of methodology has a positive effect on motivation development. However, this does not apply universally. The effect is small and above all

[8] Handlungsorientierter Unterricht. This is also called “practice-oriented learning-teaching” or “task based learing-teaching”

[9] “Inert knowledge” is the knowledge that is not (or can not be) used in practice.

[10] Key competencies are sometimes called basic competencies, central competencies, or competencies for employability (Vargas-Zuniga, 2005, p. 81)

it may only be justified if the motivation conditions mentioned here exhibit considerable positive effects. In another words “überforderte Schüler sind in handlungsorientierten Arbeitsformen ebenso wenig motiviert wie im direktiven Unterricht.” (Nickolaus, 2010a, p. 7). That means, “action-oriented methods are no more effective than directive methods when it comes to motivating students who face challenges exceeding their abilities”.

2.4. Modular and Competency Based Education and Training Approach

2.4.1. Module in Context of TVET Policy

The idea of dividing curricula into independent units, generally called ‘modules’ has originated in the USA. Modules were first introduced at Harvard University in 1869 with the aim to provide a flexible framework within which students can study a range of disciplines, with the choice to specialize to a smaller or larger extent in particular subjects (Badley & Marshall, 1995, p. 17).

In the 50s of the 20th century it was in particular B.F. Skinner’s research that helped the modular approach to spread rapidly at the American universities. With the objective of individualization of learning and in connection with the method of programmed instruction Skinner formulated teaching principles that were used as a basis in designing modules: small learning steps, active participation of learners, immediate confirmation / reinforcement, determination of the learning pace by learners themselves. This approach was supplemented by S.N. Postlethwait through the learning with audio tapes (audio tutorial approach) in the 60s (Husen & Postlethwait, 1985, cf. p. 3398 ff).

Relatively late the modular approach found entrance in vocational education and training (VET), for example, in England in years 1968. Also since the end of 60s the modular concepts for VET have been being launched by the International Labour Organisation (ILO) at the global level (Reuling, 1996, p. 48).

Due to the long-standing tradition in the Anglo-American world English dictionaries refer the educational meaning of ‘module’ as: “one of several independent units or options to make up a course of study” (OXFORD-Dictionary, 1989, p. 798 f.). From the view of educational scientists *module* is defined as: “*modules are self-contained units, which in an educational context, provide students with specific learning experiences*” [cf. (Bünning et al., 2000, p. 14); (Badley & Marshall, 1995, p. 15)]. With regard to the testing of modules it is added: “The assessment process in modular course schemes usually requires that each module is assessed on completion of its taught elements. One important consequence of modularity is therefore that each module completed by students is assumed to represent content and outcomes which they have mastered and for which they need never again to be assessed" (Badley & Marshall, 1995, p. 16).

Reuling arranges the characteristics of modular education and training courses as primary and secondary on the basis of Theodossin (Table 2.3).

Characteristics		Explanation
Primary	Certain size of modules	module size can be fixed or variable. The size is expressed in terms of lecture hours or credits
	Arrangement of modules	modules can be absolved together or successively
	Certifying per module	Modules are independent and self-contained units. They can not only be proved separately but also be taught independently
Secondary	Credit accumulation	Credit point (weight) for each absolved module can be accumulated to achieve a full qualification.
	Principles of combination	This is for structuring the full qualification into compulsory and optional modules. The possibilities of modules selection and their sequencing are pre-structured to a certain degree, so that an absolute free selection of modules to be absolved is not possible in reality
	Sharing of modules	A single module can be assigned to different occupational qualifications and / or education and training courses

Table 2.3.: Characteristics of modular education and training courses according to Theodossin (1986) (modified by Reuling 1996, p. 49)

"A module is understood as an independent, a self-contained (occupational and further) education and training unit, which has a certain size, an input defining pre-requisites and learning objectives and a controllable and certifiable output. Learners can freely or constrained choose from these modules. Modules are combinable. Thus, these lead (mostly) through so-called '*credit accumulation systems*' (Reuling, 1996) to flexible qualifications (without final exams at the end of the programme) at different levels, which are so more adaptable to individual conditions and societal demands." (Malek, 1998, p. 123).

What distinguishes such programmes from traditional courses is that they consist of a range of modules, where each module is a self-contained unit of learning. Students construct their own courses by choosing a combination of modules to study from the range on offer. Each module has its own unique set of learning outcomes. On completion of the module, students are immediately assessed on whether they have satisfied these, and they will not be reassessed on these later on in their studies. In addition, particular modules may be identified as prerequisites for other modules.

2.4.2. Competency-based Education and Training

Competency-based education and training is a concept of technical and vocational education and training, whose content is heavily oriented towards the requirements of the learner's future workplace, that allows a formal education and training programme to be delivered in a modular and individualized form and assesses fewer cognitive than work related competences (Clement, 2003, p. 129). Competency-based training (CBT) approach places emphasis on what a person can do in the workplace as a result of completing a program of training.

Basic principles and intentions of competency-based education (CBE)

Bowden points out the following basic principles and intentions of CBE:

- *a focus on outcomes* – i.e. its emphasis on the specification and assessment of outcomes (referred to as competences). This focus on outcomes is often contrasted with more traditional concerns of educational programmes with inputs such as methods of student/trainee selection, lengths of courses, class sizes, teacher-pupil ratios and so on (Spady, 1977; Johnston, 1992).
- *greater workplace relevance* – the ability to apply knowledge to perform practical tasks and to fulfil workplace roles.
- *outcomes as observable competences* – expressing outcomes as explicit, clearly observable workplace performances. The intention is to express outcomes in the form of clear and precise competences, so that (a) the needs of employment can be better communicated; (b) the goals of educational programmes can be re-defined and communicated with greater precision; and (c) straightforward judgements can be made about the extent to which any particular competency has been attained.
- *assessments as judgments of competence* – i.e. each learners achievement is measured against the competence standards rather than against the achievement of other learners.
- *improved skills recognition.*
- *improved articulation and credit transfer.*

Types of Competency-based Approaches

Since the concept of competency has been changing continuously, different ideas and competency-based training models or approaches are being developed, especially in the area of TVET. However, all of these reflect, in varying degrees, an evolution in the demand for qualifications (Tippelt & Amorós, 2003, p. 8).

The hierarchy represented in Table 2.4 shows different perspectives on what represents competence, as implied by different competency-based practices.

Table 2.4.: Competency-based education (CBE) levels according to Bowden (2009), p 5

0 Generic	Knowledge, skills and attitudes (what the competency-based movement has reacted against)	The knowledge, skills and attitudes that underlie professional competence are spelled out. But it runs the risk of attempting not considering what it is that professionals actually do in the workplace.
1 Behaviourist	Basic performance in the workplace	Occupational / professional work is analysed into roles (duties), task and sub-tasks.
2 Additive	Performance plus knowledge (usually with knowledge assessment undertaken separately from performance assessment)	This approach identifies those areas of professional practice in which it is essential to demonstrate at least minimum competence and also identifies the knowledge, skills and attitudes required to perform complex professional activities. (Gonczi 1990)
3 Integrative	Performance and knowledge integrated	The Level 3 approach attempts to consider knowledge in context, in relation to performance rather than separate from it.
4 Holistic	Holistic competence	The Level 4 approach represents the attempt to integrate also well the persons way of seeing himself / herself as a professional.

There is a series of trends from Level 1 through to Level 4. In the first place, that progression mirrors the historical development of competency-based education. The narrower, performance focused aspects represent the beginning of the movement and, over the decades, some of them in the movement have revised their thinking and developed practices further, although this has not been universal. The other trends from Level 1 to Level 4 include (ibid):

- increasing complexity of outcome,
- broader curriculum requirements,
- more complex assessment requirements,
- increasing ambiguity in the relation between objectives and assessment of outcome, and
- increasing need for interpretation and professional judgment in assessment.

Level 4 for instance represents a three-way integration among the persons way of seeing his / her professional role, his / her capacity to undertake that role and the knowledge-base with which that professional identity and performance are intermeshed. The assessment of such an outcome is not simple and it is difficult to assess it directly.

Advantages and disadvantages of competency-based education

Competency-based education is not unique in its intention to focus more sharply on educational outcomes. This intention is central to many current initiatives in education in many countries, including the development of educational performance indicators; the setting of national educational goals; the introduction of statements and profiles for key areas of the curriculum; and the development of programmes to assess and report levels of student achievement and to monitor educational standards over time. What distinguishes competency-based education from this broader orientation towards the clearer specification and monitoring of outcomes is its concern with outcomes relevant to employment (Bowden, 2009).

Under competency-based approaches, the redesign of curricula to make them more relevant to workplace requirements normally begins with an analysis and identification of workplace competencies which are then organised into a set of competency standards for an occupation.

"Explicitness and precision are recurring themes in discussions of competency-based outcomes" (Bowden, 2009, p. 4). If outcomes can be expressed in precise, observable terms, it is argued, these can then be used to set clear goals for educational programmes. For Gilbert Jessup, a leading advocate of competency-based education in the UK, precision in the specification of competencies is the key to accurate communication of workplace needs (cf. ibid.).

According to Bowden (2009, p. 4) "..the narrowness of these representations of the principle of *outcomes as observable competencies* have alienated many tertiary educators. However, it is possible to glean, from this and the other principles, some aspects which are progressive and to produce an educational design which meets the needs of a range of stakeholders. This interest in greater workplace relevance is not unique to the competency movement although its presence may have been catalytic in increased interest by universities in including professional and industry personnel in review of programme structures and curricula".

CBT's opponents consider it excessively reductionist, narrow, and rigid, as well as theoretically, empirically, and pedagogically unsound. The following are among the issues surrounding CBT: (1) the relative merits of the behaviorist and holistic approaches to CBT; (2) the question of whether CBT gives employers what they want; and (3) the question of whether CBT's curriculum is being driven by government, employers, or educational institutions) (Kerka, 1998).

In Germany, the debate over competency is closely linked to "global professional definitions which place greater emphasis on the improvement of the training process" (Tippelt & Amorós, 2003, p. 9). The German VET in the dual system provides to the trainees initial training for different occupations. It is not a modular system of VET. The modular systems employed in the UK, however, prepare students or apprentices for a group of occupations or positions too diverse as to be limited to one single profession. This conceptualisation of initial vocational training as a system of occupations that leads young people to a global professional qualification rather than a series of partial qualifications forms the basis of the holistic competency based training focus. (ibid.)

2.5. Domains of Human Learning and their Taxonomies

Bloom (1956) and his colleagues identify three domains of educational activities:

- Cognitive: connected with thinking or conscious mental processes / mental skills (Knowledge)
- Affective: growth in feelings or emotional areas (Attitude)
- Psychomotor: manual or physical skills (Skills)

Trainers often refer to these three domains as KSA (Knowledge, Skills, and Attitude). This taxonomy of learning behaviours can be thought of as "the goals of the training process." That is, after the training session, the learner should have acquired new skills, knowledge, and / or attitudes.

2.5.1. The Cognitive Domain

The cognitive domain involves knowledge and the development of intellectual skills. This includes the recall or recognition of specific facts, procedural patterns, and concepts that serve in the development of intellectual abilities and skills (Bloom 1956) . In a more recent adaptation of Bloom's taxonomy of educational objectives Anderson & Krathwohl (2001) propose a two-dimensional taxonomy for learning, teaching and assessing (Table 2.5).

Categories of the Knowledge Dimension

In the Knowledge Dimension Anderson & Krathwohl (2001) differentiate between four types of knowledge.

A. Factual Knowledge

Factual knowledge is knowledge that is basic to specific disciplines. This dimension refers to essential facts, terminology, details or elements students must know or be familiar with in order to understand a discipline or to solve any of the problems in it. *Factual knowledge* may be distinguished from *Conceptual knowledge* by virtue of its very specificity; that is, *Factual knowledge*

Table 2.5.: The Taxonomy Table. (Anderson & Krathwohl, 2001)

The Knowledge Dimension	The Cognitive Process Dimension					
	1. Remember	2. Understand	3. Apply	4. Analyze	5. Evaluate	6. Create
A. Factual Knowledge						
B. Conceptual Knowledge						
C. Procedural Knowledge						
D. Meta-Cognitive Knowledge						

can be isolated as elements or bits of information that are believed to have some value in and of themselves.

B. Conceptual Knowledge

Conceptual Knowledge includes knowledge of classifications and categories, knowledge of principles, generalizations, and knowledge of theories, models, or structures pertinent to a particular disciplinary area. It is more complex and organised knowledge form.

C. Procedural Knowledge

Procedural Knowledge refers to information or knowledge that helps students to do something specific to a discipline, subject, area of study. It also refers to methods of inquiry, very specific or finite skills, algorithms, techniques, and particular methodologies.

D. Meta-cognitive Knowledge

Meta-cognitive Knowledge is the awareness of one's own cognition and particular cognitive processes. It is strategic or reflective knowledge about how to go about solving problems, cognitive tasks, to include contextual and conditional knowledge and knowledge of self.

Categories of the Cognitive Process Dimension

There are six major categories in this dimension, which are listed in order below, starting from the simplest behavior to the most complex. The categories can be thought of as degrees of difficulties.

1. Remember

Remembering refers to retrieving, recalling, or recognizing knowledge from memory. Remembering is when memory is used to produce definitions, facts, lists, recite or retrieve material.

2. Understand

Students understand when they build connections between the "*new*" knowledge to be gained and their prior knowledge. More specifically, the incoming knowledge is integrated with existing schemas and cognitive frameworks. Since concepts are the building blocks for these schemas and frameworks, *Conceptual knowledge* provides a basis for understanding. The cognitive processes in the category of *Understand* include interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining.

3. Apply

Apply involves using procedures to perform exercises or solve problems. The *Apply* category consists of two cognitive processes: *executing* – when the task is an excercise (familiar) – and *implementing* – when the task is a problem (unfamiliar). *Implementing* requires some degree of understanding of the problem as well as of the solution procedure. In the case of *implementing*, then, to *understand conceptual knowledge* is a prerequisite to being able to *apply procedural knowledge*. *Applying* relates and refers to situations where learned material is used through products like models, presentations, interviews or simulations.

4. Analyze

Analyse means breaking material or concepts into parts, determining how the parts relate or interrelate to one another or to an overall structure or purpose. Mental actions included in this function are differentiating, organizing, and attributing, as well as being able to distinguish between the components or parts.

5. Evaluate

Evaluate is defined as making judgments based on criteria and standards through checking and critiquing. The criteria most often used are quality, effectiveness, efficiency, and consistency. The standards may be either quantitative or qualitative. The category *Evaluate* includes the cognitive processes of *checking* (judgments about the internal consistency) and *critiquing* (judgment based on external criteria). Critiques, recommendations, and reports are some of the products that can be created to demonstrate the processes of evaluation.

6. Create

Create involves putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing. Creating requires users to put parts together in a new way or synthesize parts into something new and different, a new form or product.

2.5.2. The Affective Domain

The affective domain (Krathwohl et al., 1973) includes the manner in which we deal with things emotionally, such as feelings, values, appreciation, enthusiasms, motivations, and attitudes. The five major categories are listed from the simplest behavior to the most complex:
1. Receiving. This refers to the learner's sensitivity to the existence of stimuli - awareness, willingness to receive (hear), or selected attention.

2. Responding. Responding to Phenomena is active participation on the part of the learners. Attends and reacts to a particular phenomenon. Learning outcomes may emphasize compliance in responding, willingness to respond, or satisfaction in responding (motivation).

3. Valuing. The worth or value a person attaches to a particular object, phenomenon, or behavior. This ranges from simple acceptance to the more complex state of commitment. Valuing is based on the internalization of a set of specified values, while clues to these values are expressed in the learner's overt behavior and are often identifiable.

4. Organization. Organizes values into priorities by contrasting different values, resolving conflicts between them, and creating an unique value system. The emphasis is on comparing, relating, and synthesizing values.

5. Characterisation – the Internalization of values. Internalising values (characterisation) has a value system that controls their behavior. The behavior is pervasive, consistent, predictable, and most importantly, characteristic of the learner. Instructional objectives are concerned with the student's general patterns of adjustment (personal, social, emotional).

2.5.3. The Psychomotor Domain

The psychomotor domain (Simpson, 1972) includes physical movement, coordination, and use of the motor-skill areas. Development of these skills requires practice and is measured in terms of speed, precision, distance, procedures, or techniques in execution. The seven major categories are listed from the simplest behavior to the most complex:
1. Perception. The ability to use sensory cues to guide motor activity. This ranges from sensory stimulation, through cue selection, to translation.
2. Set. Readiness to act. It includes mental, physical, and emotional sets. These three sets are dispositions that predetermine a person's response to different situations (sometimes called mindsets).

3. Guided Response. The early stages in learning a complex skill that includes imitation and trial and error. Adequacy of performance is achieved by practicing.

4. Mechanism. This is the intermediate stage in learning a complex skill. Learned responses have become habitual and the movements can be performed with some confidence and proficiency.

5. Complex Overt Response. The skillful performance of motor acts that involve complex movement patterns. Proficiency is indicated by a quick, accurate, and highly coordinated performance, requiring a minimum of energy. This category includes performing without hesitation, and automatic performance.

6. Adaptation. Skills are well developed and the individual can modify movement patterns to fit special requirements.

7. Origination. Creating new movement patterns to fit a particular situation or specific problem. Learning outcomes emphasize creativity based upon highly developed skills.

Dave (1975) presents five categories of the psychomotor domain. They are:

1. Imitation. Observing and patterning behavior after someone else. Performance may be of low quality. Example: Copying a work of art.

2. Manipulation. Being able to perform certain actions by following instructions and practicing. Example: Creating work on one's own, after taking lessons, or reading about it.

3. Precision. Refining, becoming more exact. Few errors are apparent. Example: Working and reworking something, so it will be "just right."

4. Articulation. Coordinating a series of actions, achieving harmony and internal consistency. Example: Producing a video that involves music, drama, color, sound, etc.

5. Naturalization. Having high level performance become natural, without needing to think much about it. Examples: Michael Jordan playing basketball, Nancy Lopez hitting a golf ball, etc.

Dave‘s (1975) version fits with the model of developing skills put forward by Reynolds (1965), and it also draws attention to the fundamental role of imitation in skill acquisition.

2.6. The Technical and Vocational Education and Training in Bangladesh

Bangladesh has historical links with Britain and it has inherited an education system based on the UK model (British Council 2001). The present education system of Bangladesh may be broadly divided into three major stages, viz. primary, secondary and tertiary education.

The post-primary education is classified into four types in terms of curriculum: general education, technical and vocational education, professional education and madrasah education (Figure 2.9).

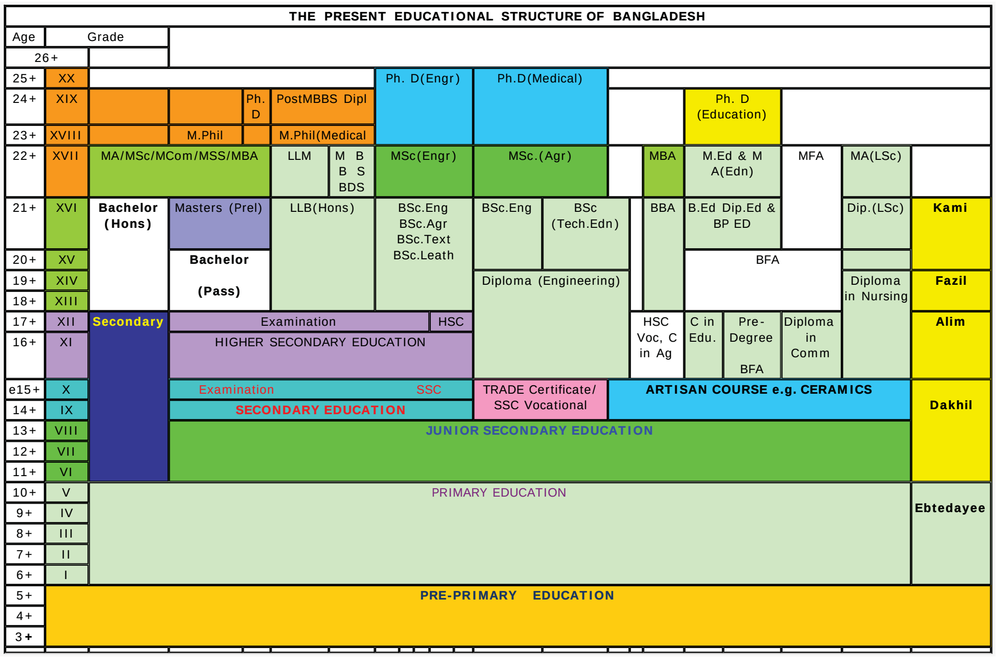


Figure 2.9.: Basic structure of the education system of Bangladesh (BANBEIS, 2010)

Primary education is comprised of 5 years of formal schooling (Class / Grades I – V). Education, at this stage, normally begins at the age of 6+ to the age of 11 years.

Secondary education is comprised of 7 (3+2+2) years of formal schooling. The first 3 years (grades VI-VIII) are referred to as junior secondary; the next 2 years (Grades IX -X) are secondary while the last 2 years (Grades XI - XII) are called higher secondary. There is a diversification of courses after three years of schooling on the junior secondary level. Vocational and technical courses are offered in vocational and trade institute / schools. Moreover, there are high schools where SSC (vocational) courses have been introduced.

Tertiary education is comprised of 3-6 years of formal schooling. The minimum requirement for admission to higher education is the higher secondary certificate (H.S.C).

Technical and Vocational Education and Training

The Technical and Vocational Education and Training (TVET) in Bangladesh operates at Certificate (secondary) and Diploma (higher secondary) level. It is offered in a range of technical specialties, such as agriculture; business; building and construction technology; clothing and textiles; electrical, electronics, computer, information & communication technology; food and nutrition; mechanical and automobile, etc. It is, generally, offered through the technical departments of secondary schools, technical schools and colleges (TSCs), polytechnic institutes and other non-government/ private training institutes. It is provided by formal, non-formal and informal means.

2.6.1. TVET at Secondary Level

Certificate (also called Vocational) courses start from secondary level. The certificate courses prepare skilled workers in different vocations starting from ninth grade after completion of three years of schooling in secondary school. At this level the courses are diversified in different occupations spread over 1 to 2 years duration.

2.6.2. TVET at Higher Secondary Level

At the higher secondary level there are two progammes - the 4-Year Diploma courses and the 2-Year Higher Secondary School Certificate (Vocational) courses.

The *4-Year Diploma* courses (mid level technical education programme) prepare the diploma engineers at the mono/ polytechnic institutes. These courses spread over 4 years duration. The prerequisite for these courses is the secondary school certificate (10 years schooling). They are full-time school based, including 1 industrial attachment semester. They are offered in 28 different technological areas in 41 government polytechnic institutes and 4 specialised institutes. There are more than 100 private polytechnic institutes offering Diploma in Engineering courses mainly in computer and electronics technology (DTE, 2010).

The *2-Year Higher Secondary School Certificate (Vocational) (the H.S.C.(Voc))* courses have been introduced more recently at the higher secondary level mainly in government managed vocational training institutes (VTIs)(renamed as technical school & college (TSC)).

Examination

Diploma-in-Engineering programme: The 4-year diploma engineering course in Bangladesh is divided into 8 semesters. There is continuous assessment (class participation, attendance, homework, etc.), where students are assessed by class teachers over the whole semester, and a final examination held at the end of each semester. The final result is published as cumulative grade point average (CGPA). Qualifications are awarded by BTEB at the end of four years (minimum requirement) upon successfully passing the examiantions. Because a student has to accumulate a fixed number of credits which are distributed over the four years, a qualification in a time shorter than four years is not possible. Thus the minimum duration of the diploma programme is four years.

H.S.C. (Voc) programme: There is a final examination at the end of two years. Certificates are awarded based on these examination results.

2.7. The Vocational Education and Training (VET) in Germany

2.7.1. Background to the VET System

In Germany children enter compulsory full-time schooling aged 6. This schooling period lasts 9 to 13 years. After 4 years of primary school, pupils move into different educational branches: either secondary general school (Hauptschule, classes 5 to 9), intermediate school (Realschule, classes 5 to 10) or grammar school (Gymnasium, classes 5 to 10, plus 11 to 12/13). Often these different pathways merge through the dual system (Section 2.7.3– VET at Upper Secondary Level) (ReferNet-Germany, 2009, p. 29).

Figure 2.10 provides an overview of the basic structure of the education/ training sector in the Federal Republic of Germany, divided by training areas/ types of schools.

The various qualifications and the competences that result from various channel of education are aligned to ISCED and have not yet been aligned to the levels of a National Qualifications Framework. The German Qualifications Framework (DQR) is still being developed (ibid.).

2.7.2. Vocational Education and Training at lower Secondary Level

Lower secondary education comprises grades 5 to 10 or 7 to 10 of school (pupils are aged 10-15). Its function is to prepare pupils for upper secondary level. Accordingly, lower secondary education is predominantly of a general nature. Lower secondary education is public and free of charge (ibid, p. 31).

At secondary general school (Hauptschule) and intermediate school (Realschule) an introduction to the world of work is a compulsory component of all courses. Instruction is given either in a separate subject (pre-vocational studies - Arbeitslehre) or as part of the material used in other subjects. Work experience placements, especially for pupils in the two last grades provide first-hand insight into the world of work and guidance in choosing an occupation. The states (Länder) have continuously developed their activities in order to communicate a basic knowledge of the world of business and commerce. This has also taken place outside of lessons,

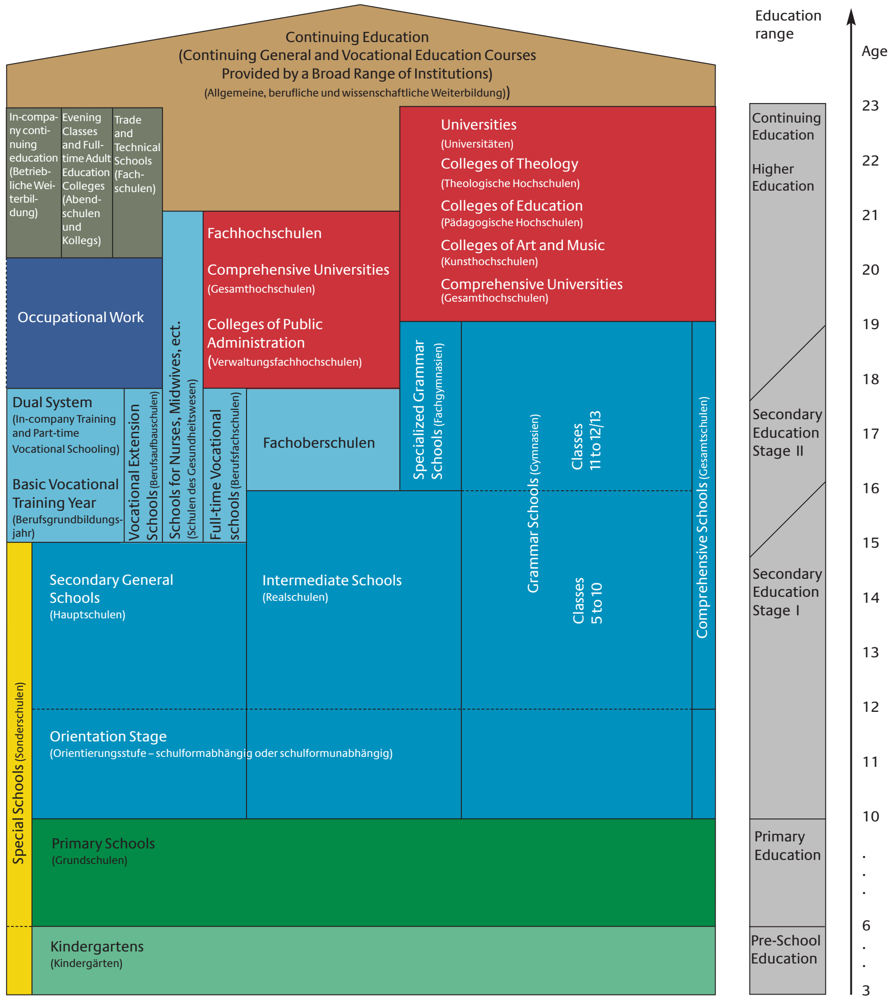


Figure 2.10.: Basic structure of the education system of the Federal Republic of Germany. (ReferNet-Germany, 2009, p. 30)

for example, via model businesses set up by pupils (Schülerfirmen) or cooperation projects between the schools and the world of business and commerce (ReferNet-Germany, 2009, p. 31).

After finishing lower secondary level education and completing compulsory schooling, pupils may enter into vocational training in full time schools or within the framework of the dual system (Section 2.7.4) or seek employment.

For those who do not start a regular vocational course there is compulsory vocationally oriented schooling in a pre-vocational training year (Berufsvorbereitungsjahr - BVJ). Their typical age would be 15 or 16. Participants are socially disadvantaged, have learning difficulties or are migrants with an inadequate command of German who need special assistance to begin and complete a course of training. Young people who are not yet ready to enter vocational training have to participate in a full time pre-vocational training year, which serves as a vocational orientation and an introduction to one, two or three occupational fields (ibid.).

2.7.3. VET at Upper Secondary Level

Upper secondary education leads either to a higher education entrance qualification or a vocational qualification for skilled work. The vocational track means that pupils may enter into vocational training in full time schools or within the framework of the dual system (Section 2.7.4), or seek employment (ReferNet-Germany, 2009, p. 32).

School-based VET (vollzeitschulische Berufsausbildung) at upper secondary level includes the Berufsfachschule, the Fachoberschule, the Berufliches Gymnasium or Fachgymnasium and other types of school that exist only in individual Länder or only on a very small scale.

Young people with social disadvantages, learning difficulties or handicaps and young people with migrant backgrounds with an inadequate command of German have different possibilities for pre-vocational training (Berufsausbildungsvorbereitung - Section 2.7.5) (ibid.).

Full-time vocational schools (Berufsfachschulen) introduce students to one or more occupations, provide them with partial vocational training in one or more training occupations, or take them through to a vocational training qualification in one occupation. The range of training provision in schools of this type is extremely diverse. There are full-time vocational schools, for example, commercial occupations, occupations involving foreign languages, craft occupations, household and caring occupations, health care occupations and artistic occupations. Depending on the training goal being pursued, access requirements are either a lower secondary school or intermediate secondary school leaving certificate. These correspond to ISCED Level 2. No occupational experience of any kind is required. Most pupils are aged 15 when they commence full-time vocational school. Pupils who complete full-time vocational school attain ISCED Level 3. Part-time teaching is offered at some full-time vocational schools (ibid.).

Where these schools do not offer a full vocational qualification, attendance at a full-time vocational school can be credited as the first year of vocational training in the dual system if certain conditions are met. The requirement for entrance is normally the secondary general school certificate or the final certificate from intermediate school. The duration of educational programmes at full-time vocational schools varies (from one to three years) depending on the specialisation (ReferNet-Germany, 2009, p. 32).

Senior technical schools (Fachoberschulen) (and senior vocational schools (Berufsoberschulen)) cover classes 11 and 12 and build on the final certificate from intermediate school (Mittlerer Schulabschluss) or a qualification recognised as equivalent. The first year comprises in-company specialised practical training and teaching, while the second year involves general and specialised teaching. It leads to the academic standard required for entrance to a university of applied science (Fachhochschule). Students who have completed a course of vocational training, e.g. dual training, can enter class 12 of a Fachoberschule directly (ibid.).

2.7.4. Apprenticeship Training in the Dual System

The system is described as dual (1) because training is conducted in two places of learning: companies and vocational schools; and (2) since the basis of laws and responsibilities for the two palaces are different: the legal framework for on-the job training at companies consists of the national Crafts Act for the craft sector and the national Vocational Training Act for all other vocational sectors, whereas the school-based training operates under state jurisdiction (Hellwig, 2006, p. 3). It normally lasts three or three and one-half years (some occupations only require two years and there are also regulations allowing a reduction in the training period for trainees with an Abitur - the school leaving certificate allowing entry to higher education). The trainees are in the average between 16 and 18 years old at the beginning of the education and training (ReferNet-Germany, 2009, p. 34, ff.).

The aim of training in the dual system is to provide, in a well-ordered training programme, broad-based basic vocational training and the qualifications and competences required to practice an occupation as a skilled worker in one of the 348 currently recognised training occupations [BIBB (2010); VET in Europe - Country Report 2009]. Compulsory full-time education must have been completed by the time of commencing vocational training. There are no further requirements for access to training in the dual system; it is essentially open to all although the majority of trainees hold either the Intermediate Certificate (the Abitur) or the Certificate of Secondary Education (Hauptschulabschluss / Realschulabschluss) (ibid.).

The professional competences in occupations to be acquired in in-company training are specified in a training regulation and included by the training enterprise in an individual training plan. For the teaching in the vocational school, a framework curriculum, harmonised with the training regulations, is drawn up for every recognised training occupation.

Enterprises as Place of Learning

Training places are offered in both private and public enterprises, in practices of the liberal professions and, to a very limited extent, also in private households. Enterprises enter into a contract with trainees, in which they undertake to provide them with the professional competences in the occupation provided for in the training regulation for the relevant training occupation (ReferNet-Germany, 2009, p. 35).

The binding requirements of the training regulations guarantee a uniform national standard which corresponds to the requirements in the relevant occupation. Training may take place only in training enterprises in which the skills required by the training regulation can be imparted by training personnel who are appropriate both personally and in terms of specialised knowledge. The suitability of training enterprises and in-company training personnel is monitored by the relevant autonomous industrial bodies (Chambers). Proper provision of the training itself is also monitored by the Chambers (ibid.).

The training enterprise draws up an in-company training plan for trainees, which must correspond to the training regulation in terms of its practical and time structure, but may deviate from it if particular features of company practice require it (ibid.).

Small and medium-sized enterprises are often unable to provide all the learning content: they may lack suitable training personnel, or, owing to their particular specialisation, they do not cover all the training content themselves. There are various ways of overcoming these problems (ReferNet-Germany, 2009, p. 35, ff.):

- Educational institutions offer inter-company training periods (inter-company vocational training centres – ÜBS), designed to supplement in-company training. They are often sponsored by autonomous bodies in the relevant sectors of industry. The Federal Ministry for Education supports the sponsors with investment subsidies. The BIBB bears statutory responsibility for implementing the sponsorship.
- Enterprises form coherent training structures (Ausbildungsverbünde). There are four traditional models for this, e.g. the lead enterprise with partner enterprise model, in which the lead enterprise bears overall responsibility for training, but parts of the training are conducted in various partner enterprises, or the training to order model, in which some periods of training take place outside the regular enterprise, perhaps in a nearby large enterprise with a training workshop, on the basis of an order and against reimbursement of costs.

Vocational School as a Place of Learning

In the dual system, the vocational school is an autonomous place of learning. Its task is to provide basic and specialised vocational training and to extend previously acquired general education (ReferNet-Germany, 2009, p. 35, ff.).

Under a KMK (1991) decision , vocational schools must provide at least 12 hours teaching a week, normally eight hours for vocational subjects and four hours to general subjects such as German, social studies / business studies, religious education and sport. Appropriate account is also to be taken of foreign language teaching, depending on its importance to the training occupation concerned. Vocational schools decide on how to allocate teaching in consultation with training enterprises, the schools inspectorate and the competent industrial bodies. The aim of the various organisational forms is to ensure that trainees spend as much time in the enterprise as possible while, at the same time, allocating teaching in a way that is tenable in terms of both pedagogics and the psychology of learning.

Examination

The primary aim of training is to enable young people to acquire comprehensive vocational competence designed to make them capable of fulfilling their duties as employees efficiently, effectively and innovatively, autonomously, and in cooperation with others. Vocational competence is based on subject-based, social and methodological competences. The capacity to practise an occupation in a qualified fashion includes, in particular, autonomous planning, implementation and control. This bundle of competences must be demonstrated in examinations regulated by law (Vocational Education and Training Act).

Final training examinations are geared to vocational practice, i.e. to the work requirements and processes of the occupation. As a rule, a final examination covers four or five fields typical of the occupation. Performance in general subjects, such as languages and mathematics, is evaluated within the framework of school reports. Various methods are used in examinations depending on the occupation and duration may vary especially in practical examination tasks. For written tasks, a period of two hours is usually allocated for the examination, and oral examinations usually last 30 minutes.

Enterprises and vocational schools conduct training, but the Chambers (Competent Bodies) are responsible for holding examinations. To this end, the Chambers have to set up examination committees for each occupation which comprise at least three members (one representative each of employers and employees and a vocational schoolteacher). The examination certificate is issued by the Chamber. The structure of examinations is laid down by individual training regulations which are applicable nationwide and specify a uniform standard.

Statistical Data

The dual system is the largest provider of education at upper secondary level. It corresponds to ISCED level 3B. The average duration of the course is three (3) years. In 2008, 67,7% (616.259) of the school-leavers (909.783) from general education opted for a dual-system apprenticeship (BMBF, 2009, p. 15).

2.7.5. Other Youth Programmes and alternative Pathways

For people with learning difficulties or social disadvantages who would find it difficult to participate in a recognised training occupation or equivalent vocational training, there is the option of pre-vocational training (Berufsausbildungsvorbereitung) (ReferNet-Germany, 2009).

3. The Research Questions and Hypotheses

3.1. The Research Questions

While Bangladesh's national job market can hardly accommodate its polytechnic graduates (diploma engineers), the polytechnic section, together with other institutions in the Technical and Vocational Education and Training (TVET) sub-sector, has nevertheless been expanding rapidly, both in public and private sectors. Further increase in the TVET enrolment from currently 3% to 20% of all secondary students within the next five years (2010 – 2015) is being planned with the aim of exporting more manpower, particularly skilled technicians and workers. However, for adequate employment of these graduates in their relevant occupational area on national and international job markets their officially awarded qualifications may not be sufficient. They also have to demonstrate competences required at the workplace.

Therefore, in this research work the author wishes to examine the Diploma-in-Engineering (Electronics Technology) programme outcomes with the following research questions, among others:

Is the focus of Bangladeshi Diploma-in-Engineering curriculum more on practical / workplace relevant skills and knowledge, or on theoretical knowledge?
Are the competences acquired by Bangladeshi polytechnic graduates comparable to those of a developed country, for example Germany? More specifically, how good are Bangladeshi polytechnic students at different cognitive levels (reproduction through transfer) compared to Germany?
What makes Bangladesh different from Germany particularly in student assessment approaches?
Are teachers able to judge their students without taking a test?
Do the student performances differ among schools / classes?

This research work explores the real situation of Bangladesh, particularly for the occupation "Diploma in Engineering (Electronic Technology)" and tries to find the answers to the above questions. The investigation is, led by the hypotheses given in the following Section.

3.2. The Hypotheses

3.2.1. The Competency Level of Polytechnic Graduates in Bangladesh

The quality or the occupational competency of the polytechnic graduates in Bangladesh has been doubted for a long time. But no (or only little) quantitative empirical research or few studies have been conducted so far. A qualitative study report mentioned, ".. private sector employers in particular seem to be somewhat sceptical about the skills and abilities of polytechnic graduates and appear sometimes to prefer to recruit from alternative sources, such as well-qualified school-leavers" (Oxtoby, 1997, p. 94). Similar statements have recently been made by some experts / teachers when the author conducted interviews with them in February 2010. For example, polytechnic teachers complain that the basic competences (literacy, numeracy, ICT, etc.) demonstrated by students at the entry stage of the Diploma course show an insufficient level of education and skills. These shortcomings at the entry stage, together with other factors hinder educating graduates with high level competences.

On the other hand, Germany has been endeavouring to further the competency level of its VET-graduates, although its VET system has been enjoying an excellent reputation on the international level, especially the dual apprenticeship system. For example, the introduction of the learning field concept eliminating the traditionally subject-based curriculum and the introduction of action-oriented learning-teaching arrangements, among other things[1]. The VET system in Germany offers well established infrastructures, well equipped laboratory settings, sufficient supply of raw-materials, learning materials and ICT facilities for the trainees. Moreover, the trainees are often well supported by their families and / or the social systems in comparison to Bangladesh. All of these factors can not be matched in Bangladesh.

Nevertheless, on the above basis in this part of research the author investigates empirically the present situation (the diploma programme outcomes – in the area of electronics technology) with the hypothesis, that:

Hypothesis H1: *The competency level, in the case of application-oriented tasks, achieved by the polytechnic students/graduates in Bangladesh at the end of the Four-Year Diploma-in-Engineering course, is lower than that of the vocational school (Berufsschule) trainees in Germany at the end of the Three-and-One-Half-Year Apprenticeship Training in the Dual System.*

[1] A detail description of the factors that influence the development of competences of students is given in Section 2.3

In order to test this hypothesis, a quantitative measurement of the technical competence[2] of the polytechnic students / graduates in Bangladesh and that of the trainees in Germany will be carried out at field level. For the purpose of measuring the technical competencies of students two main aspects will be taken into account: a) Knowledge / understanding of subject matters and b) the ability to transfer this knowledge in solving real world relevant tasks ((Nickolaus, 2010, p. 4); with references to Geißel 2008; Nickolaus at al. 2009; Seeber 2008; Achtenhagen & Winther 2009). To determine the level of technical competence the characteristics of complexity of tasks in a situation play an important role, for example the number of variables, interconnectedness, dynamism and transparency (cf. Nicklaus 2010; with reference to Franke 2005). Another important factor in this context is the taxonomy of learning objectives, for example Bloom et al. (1956) and / or Anderson & Krathwohl (2001). Details of the measurement of competencies of students are given in Chapter 5. The measured data will be analyzed quantitatively in order to support or disprove this hypothesis.

3.2.2. Student Performance at Different Cognitive Levels

Bloom et al. (1956) defines six categories (cognitive levels) of cognitive processes, known as the taxonomy of cognitive domain. Later Anderson & Krathwohl (2001) redefined it with some changes (Table 2.5). These categories are (listed in order, starting from the simplest behavior to the most complex): *Remember* (level 1: 'reproduction' – recognising, recalling), *Understand* (level 2: 're-organisation' – interpreting, exemplifying, classifying, comparing, explaining), *Apply* (level 3: 'transfer' – executing, implementing), *Analyze*, *Evaluate* and *Create*. The categories can be thought of as different levels of difficulties. On the reproductive level a learner is simply able to describe and replicate what was taught in the classroom, or learned from textbook, or from other media. Doing so he or she can solve only some specific and previously known tasks. They are on the second level, the re-organisation level, when they can combine and interpret task-related facts and concepts. At the transfer level (level 3) learners apply all relevant facts and concepts. Moreover, at this level they are able to transfer relevant task-related information to make their decision in an integrated and well-founded way (Winther & Achtenhagen, 2009).

Research results show that students' knowledge transfer capability develops with solving similar tasks. For example, Scheiter (2004) states ".. Learning processes are mainly supported by a simple-to-complex sequence, whereas transfer is facilitated particularly if structurally similar problems are solved in succession." She adds ".. findings on analogical transfer suggest that transfer does not occur automatically for these problems (knowledge-rich problems); rather

[2]This is also called the domain specific competence or the professional competence. Here it is assumed that this dimension of competence is the dominant part and it shares the major areas of the occupational competence of an worker in his or her occupation. Further, it is to be noted that the technical competence can not be parted totally from other types of competences.

it depends on whether a problem solver is able to recognize potential structural similarities among problems." This is probably why TVET curriculum developers suggest that a TVET curriculum should imitate the workplace (Dunbar, 2002, p. 31). It should also be taken into account that occupational tasks can be performed rarely with the reproduction of existing knowledge (epistemic structure), but rather based on the production of knowledge in situations in order to come up with solutions for the tasks (heuristic structure). (Becker & Spöttl, 2008, p. 30)

Above all, the main objective of the TVET curriculum development and delivery is to assist learners in preparing for their future workplace, so that they can transfer and generate skills and knowledge (Wissensproduktion) and apply them onto solving occupational tasks and / or problems. The author assumes that students do not achieve a satisfactory level of the expected learning outcomes (in terms of preset objectives in curricula) at the end of the training course. Therefore, the following hypothesis is formed:

Hypothesis H2: *The tasks, which require only knowledge reproduction, are solved correctly with a higher probability than the tasks, which require higher level cognitive processes.*

In order to test this hypothesis student competency in different cognitive categories will be measured. That is, the test instrument will consist of test items that belong to at least three different cognitive categories ranging from *Remember* through to *Understand* and *Apply* (plus *Analyze*). Here the two data sets (the test results) of the two countries will be integrated and then analyzed. Variance analysis (ANOVA) will be applied to compare the data among these three categories.

3.2.3. A Comparison of Student Performance: at Different Cognitive Levels in Bangladesh and Germany

It is very common that in almost every curriculum the learning objectives are set very high. How many of these set objectives are achieved by the learners is often either overlooked, or not assessed. The students' learning achievement on different cognitive levels may differ between Bangladesh and Germany, maybe because the TVET systems in both countries differ greatly in terms of organisational variants, curriculum structures, learning / teaching approaches, to name but a few[3].

For example, in Bangladesh the Diploma level courses are offered in a full-time school based system at mono- / polytechnic institutes, except one industrial attachment semester. The cur-

[3]Some factors are mentioned in Section 3.2.1. A detailed description of the factors that influence the development of competences of students is given in Section 2.3

riculum is inflexible and structured in subjects. It is delivered mostly using the traditional teaching approach (directive subject systematic).

In Germany, on the other hand, the main stream vocational education and training (VET) is offered in dual system - two independent learning places: vocational schools and enterprises. Other major factors that differ with Bangladesh, are the flexible curriculum structured in '*Learning Fields*' (Section 2.1.4.2), curriculum delivery methods, and student assessment approaches. For example, besides traditional teaching methods, the curriculum is delivered through a variety of other learning / teaching arrangements such as self-directed action-oriented learning-teaching (selbstgesteuert-handlungsorientierter Unterricht) in Germany and it is empirically found that different learning / teaching approaches, among other things, can have different effects on learner's competence development [Nickolaus & Bickmann (2002); Nickolaus et al. (2005); Nickolaus et al. (2006); Geissel 2008; Knöll (2007)].

On the basis of the above mentioned factors that contribute to the development of student competence it can be assumed that Bangladeshi students show poor performance in this test, particularly on level 3 (the transfer level or the *Apply* level). This assumption may be true because of many potential problems (some are mentioned in Section 1.2) that have been ruling the TVET system in Bangladesh. But, due to other reasons (e.g. motivation, individual characteristics of learners, etc.) the opposite may also be true.

Therefore, the following hypothesis is formulated to examine how these two groups differ in performance in different cognitive categories, particularly when a student has to transfer his or her knowledge to solve tasks / problems in the cognitive process category '*Apply*':

Hypothesis H3: *In answering the tasks that demand mainly higher level cognitive processes, the performance level differs notably between the polytechnic students in Bangladesh and vocational school trainees in Germany.*

This hypothesis is a variant of the one stated above in Subsection 3.2.2, except that here student performance will be compared to see how these two countries differ with the increasing complexity of tasks. Therefore, in order to test this hypothesis student competency in different cognitive categories will be measured using the same set questionnaire used to test the above hypothesis H2. That is, the test instrument will consist of test items that belong to at least three different cognitive categories ranging from '*Remember*' through '*Understand*' to '*Apply*'. But in this case the data (the test results) of both countries will be analyzed separately, where each category of data will be compared between two countries. For example, a comparison between the students in Bangladesh and the trainees in Germany on cognitive category level 1 (category '*Remember*' – knowledge reproduction), a comparison between the students in Bangladesh and the trainees in Germany on cognitive category on level 2 (category '*Understand*' – re-organisation and / or knowledge production), and so on. A comparison among these three categories will be made using the variance analysis (ANOVA).

The investigation will be done in the following two cases: 1) the performance difference between the two countries in each of the three cognitive process categories '*Remember*', '*Understand*' and '*Apply*' according to Bloom's (1956) taxonomy, i.e. independent of knowledge types (Factual, Conceptual, Procedural, and meta cognitive combined, i.e.) and 2) the performance difference between the two countries in cognitive process category '*Apply*' according to Anderson & Krathwohl (2001) (with knowledge type Declarative (Factual & Conceptual) and knowledge type Procedural separately. In each case a variance analysis will be used.

3.2.4. Teachers' Capability of Estimating their Students' Performance

The assessment of the competency of students is one of the most important tasks facing a teacher. The importance of a teacher's role in student assessment has increased further, due to the move to a more student-centered view of learning which has required a fundamental shift in the role of the teacher. Student assessment represents a distinct and potentially separate role for the teacher. Thus it is possible that a teacher has a very good instructional quality but he or she may not be an expert examiner.

In order to be able to assess student performance a teacher has to have, among other factors, expertise in his or her particular occupational field and diagnostic competence. The student-teacher relationship (affective domain) is also a determining factor for being able to make a correct judgment of students by a teacher. "A teacher is to know his or her students individually, to probe the innermost depths of their hearts as well as examining the outer details of their lives" (Gal-Einai, 2010). A teacher is to take time to reflect upon his / her students' progress. As the teacher's familiarity grows, so the potency of his / her advice deepens proportionately (ibid).
In this piece of work the author examines if teachers can estimate the students' capability to solve particular tasks relevant to their field of study / training, without taking any real test. In order to see the real picture of this the following hypothesis is formed:

Hypothesis H4: *The teachers are in a position to estimate the solution probability of the tasks to be presented to their students.*

To justify the above hypothesis teachers of polytechnics in Bangladesh and of vocational schools in Germany will be supplied with a questionnaire, that will later be presented to their students for the competency test. This questionnaire includes 16 tasks. For each task teachers will be asked to estimate (in advance) the probability that their students will be able to answer the question(s) related to each task correctly. Teachers will put this probability value on a five-point scale varying from 1 to 5. Then students will take the test.

Finally, the teachers' assessment (the estimated probability) and the test result (the student's performance) will be analyzed quantitatively (a statistical correlation test) in order to find any correlation between these two sets of data. In this test the data of the two countries (Bangladesh and Germany) will be analyzed separately.

3.2.5. Comparison of Inter School/ Class Performance

All polytechnic institutes in Bangladesh follow a common curriculum developed by Bangladesh Technical Education Board (BTEB). This curriculum is structured in subjects and inflexible. But polytechnic institutes differ among themselves in several ways such as the location, management, ownership, learning resource, teaching staff, and so on. For example, there are government run and non-government (private and non-government organisation (NGO)) run polytechnic institutes. Some polytechnic institutes are located in the capital, very near to two central controlling and monitoring bodies, DTE and BTEB, and some are in remote districts. Besides, there are gender based institutes, for example, in four divisional cities there are four women polytechnic institutes. Polytechnics in remote districts often suffer from a serious shortage of teachers, among other things. Therefore, it is probable that the student performance between these institutes / classes differs, although the same curriculum content is (or is expected to be) delivered. Moreover, the characteristics of students play also an important role.

German vocational schools follow the *learning field* based curriculum for dual system apprenticeship training courses (Section 2.1.4.2 describes *learning field* based curriculum). In this curriculum the content is not mentioned explicitly, rather it consists of 12 to 14 learning fields. A teacher has to develop *Learning situations* within the given *Learning fields* in order to implement the curriculum. They have to think about the learning objectives and the competence requirements for their trainees. Then they have to decide which learning actions are necessary to develop these competences and so on. After this, from the didactic point of view realistic learning assignments are to be formulated as complete action. That means, a vocational school teacher has to determine the curriculum content. (Bräuer et al., 2007, p. 161).

Due to the above facts, there could be a big difference of student performance among schools or classes and, therefore, the following hypothesis is formed:

Hypothesis H5: *The student performance between schools/ classes differs significantly.*

A survey of student performance that includes six classes of five polytechnic institutes in Bangladesh and eleven classes of seven vocational schools in Germany will be conducted. The test results will be analyzed to find out if the student performances in the test differ between schools/ classes in Germany and also in Bangladesh.

3.2.6. Student Assessment Approach in Bangladesh and Germany

Student assessment is one of the key issues in the TVET curriculum. A good assessment measures meaningful learning-teaching process outcomes. The types of assessments selected should measure the learning objectives stated in curriculum and be consistent with course activities.

The student assessment approach in Bangladesh differs largely from that of Germany. A review on the examination question papers for *Diploma-in-Enineering (Electronics Technology)* examination in Bangladesh and the examination papers for apprenticeship training final examination in Germany, reveals big discrepancies. The BTEB question papers assess mainly the theoretical and reproductive knowledge. The student assessment approach in Germany is different. Here, the main focus is on measuring the student's practical relevant knowledge and skills. In order to investigate this practice, the following hypothesis is formulated:

Hypothesis H6: *The student assessment approaches in Bangladesh and Germany differ greatly regarding their theoretical requirements and practical relevance.*

To prove this hypothesis, a qualitative analysis of the items in the question papers (content analysis) will be made in order to assess if they are practical relevant or not. Within this piece of work, a question item will be considered as practical relevant if there is a possibility that the knowledge and skills related to this item will be used later in learner's future work place (knowledge transfer/ utilization). For example, students of electronics technology learn a (computer) programming language (e.g. Assembly, C). If students are asked to write a programme using the *C language* to implement a database or to calculate the first ten *Fibonacci numbers*, this question item will be classified as theoretical. But, if they are asked to write a piece of programme using the *C language* that should read a ‘button’ situated in an officer’s room and send the message “make a cup of coffee” to the coffee machine in the kitchen, for example, then this item will be considered as practical relevant, because it is domain specific problem.

For further evidence, a quantitative comparison will be made. In this quantitative analysis the tasks / items in the examination question papers of Bangladesh and Germany will be analyzed and the content will be classified according to Anderson & Krathwohl’s (2001) taxonomy of learning objectives (reproduction / re-organize / transfer). A quantitative comparison between the two countries will be made in order to see which country focuses on which level in measuring their students’ skills and knowledge.

4. Curriculum Content Analysis

4.1. Occupational Profiles and Occupational Standards

4.1.1. Occupation and Job

Webster's dictionary defines an occupation as "the principal business of one's life". It is "the generally permanent execution of interconnected activities which is paid for and which predominantly takes up the capacity for work and the working time" (Raddatz & Schröter, 1999, p. 44). It forms the life of a person and contributes essentially to his / her self-realisation and personal development (ibid.). A job is "hire for a given service or period". Jobs are time bound and tied to individual employers. An occupation is a more general concept than a job. An occupation relates to a person and his / her role in the labour market (e.g., electronic technician). The concept of an occupation (a vocation) has four main characteristics:
1) individuality (inclinations, interests, and suitability of the individual); 2) commerciality (inclome, economic interests); 3) functionality (division of labour, qualifications, performance); and 4) dynamism (adaptation, further education, change of vocation) (Nölker, 1985, p. 36). Occupational standards need to be developed around occupations and not jobs.

4.1.2. Occupational Standards versus Education and Training Standards

Occupational standards are defined in terms of the activities performed by a person in a selected occupation. An occupational standard is a detailed listing of all major activities that a worker must perform in the occupation. It differs from an occupational description (occupational profile) which is a brief general statement describing an occupation (Fretwell et al., 2001, p. 17).

Education and training standards (or curricula) are developed from the activities defined in occupational standards, and they *include learning objectives to ensure that the necessary skills and knowledge* are developed by a person to enable him or her to function at an agreed level in an occupation (ibid.) .

4.2. Recognised Training Occupations in Bangladesh

4.2.1. A List of Recognised Training Occupations in EE and ICT Fields in Bangladesh

As mentined earlier in Section 2.6, the technical and vocational education and training (TVET) in Bangladesh operates at Certificate (secondary) and Diploma (higher secondary) level. It is offered in a range of technical specialties such as agriculture; business; building and construction technology; clothing and textiles; electrical, electronics, computer, information & communication technology; food and nutrition; mechanical and automobile, etc. There is no Technical and Vocational Training Act in Bangladesh. However, Bangladesh Technical Education Board (BTEB) develops and regulates the training occupations in Bangladesh.

In the fields of electrical & electronics (EE) technology and information & communication technology (ICT) the following courses are offered at Diploma level (BTEB, 2009):
Diploma-in-Engineering in Electrical Technology, Electronics Technology, Computer Technology, Computer Science and Technology, Data Telecommunication & Networking Technology, Electro-medical Technology, Instrumentation & Process Control Technology and Telecommunication Technology.

Some other relevant occupations are: Diploma-in-Engineering in Mechatronics Technology, Automobile Technology, and Refrigeration & Air Conditioning Technology.

4.2.2. Fields of Activities, Duties and Responsibilities of a Diploma Engineer

In Bangladesh the fields of activities, duties and responsibilities (the occupational descriptions / profiles)) of a Diploma Engineer in his / her occupation, have not been defined yet. The *Diploma-in-Engineering* courses listed in Section 4.2.1 are run on the basis of the syllabuses[1] developed by Bangladesh Technical Education Board (BTEB).

---

[1] A syllabus is (a plan showing) the subjects (or books) to be studied in a particular course. It was described in Section 2.1.2

4.3. Recognised Training Occupations in Germany

4.3.1. A List of Recognised Training Occupations in EE and ICT Fields in Germany

All in all, there are about 350 state recognized training occupations in Germany BMBF (2010). These are nationally regulated in training regulations on the basis of the Vocational Training Act (BBiG) or of the Crafts and Trade Code (HwO).

In the particular fields of electrical & electronics (EE) and information & communication technology (ICT) in Germany, the following training courses are offered, among others, (BIBB, 2009):

Electronics technician for automation technology, building and infrastructure systems, devices and systems, industrial engineering, machines and drives technology, information and telecommunications technology.

Some other recognised occupations relevant to EE and ICT are, for example, automobile mechatronics technician and aerospace systems technician.

4.3.2. Fields of Activities, Duties and Responsibilities of an Electronics Technician

The initial apprenticeship training at vocational schools (Berufsschulen) in Germany is provided on the basis of the framework curriculum developed by KMK. The fields of activities, duties and responsibilities of electronics technicians listed in the foregoing Section 4.3.1 are described as follows (BIBB):

Electronics technicians for automation technology integrate, put into operation and maintain automation solutions.

Typical fields of activity are for example production automation, process automation, network automation, traffic management systems and building automation systems.

Electronics Technicians for building and infrastructure systems provide technical and organizational services. They maintain, monitor, control and secure building and infrastructure systems. They can also be employed in the construction of building and infrastructure systems.

Typical sites of employment are residential and commercial buildings, factory buildings, functional buildings such as hospitals, infrastructure facilities and industrial plants.

Electronics technicians for devices and systems produce, put into operation and maintain components and devices.
Typical fields of activity are information and communications technology devices, medical devices, automotive systems, systems components, sensors, actuators, micro systems, EMS (electronic manufacturing services), measurement and testing technology.

Electronics technician for industrial engineering assemble, put into operation and maintain technical systems for the power supply, measurement and control, communications, signaling, propulsion and lighting. Other tasks include the operation of these systems and facilities.

Typical fields of activity are electricity and power distribution facilities and networks, installations and networks in buildings, factory facilities, production and process engineering facilities, switch and control gear as well as electro-technical equipment.

Electronics technician for motors and drive technology manufacture windings, assemble, put into operation and maintain electrical machines and drive systems. Typical fields of activity are manufacturing facilities, service divisions, construction sites and test laboratories.

Electronics technicians for information and telecommunications technology deal with the construction, setting up and servicing of electrical plants in the fields of information and communications technology.
They make conception and design data transmission and data processing installations, analyze risk and damage potentials and make conception and install safety, monitoring and surveillance techniques. They install data networks, fire and burglar alarm systems, access control systems, video monitoring systems, telecommunication installation, erect and operate these installations. They install, configure and parameterize software, develop software, test IT-systems.

Moreover, electronics technicians work independently, take economic and environmental concerns into consideration and observe the relevant technical regulations and safety rules and coordinate their work with the preceding and following activities. They often work as part of a team. They are qualified electricians within the meaning of the accident prevention regulations.

4.4. Content Analysis of the Diploma-in-Engineering Curriculum in Bangladesh

Bangladesh Technical Education Board (BTEB) develops and reviews curricula for technical and vocational eduction and training (TVET) courses in Bangladesh. As mentioned earlier, this study concentrates on the particular occupation of *Diploma-in-Engineering (Electronics Technology)*. Therefore, the following sections of this chapter deal with the curriculum for this particular training course.

4.4.1. The Content of the Diploma-in-Engineering (Electronics Technology) Curriculum

The content of the *Diploma-in-Engineering* curriculum / syllabus is organised according to subjects. The subjects taught in the *Diploma-in-Engineering (Electronics Technology)* course can be divided into two major categories: the technical (domain specific) subjects and the related subjects. However, for the purpose of analysis and to make a comparison with German curriculum for vocational schools, these subjects have been grouped into (1) domain specific (e.g. electronics, electrical, and information technology; (2) mathematics and natural science; (3) other related subjects (management, book keeping, social science, language, environment, entrepreneurship, etc. and (4) industrial training.

The **technical (domain specific) subjects**, as found in BTEB syllabus (2009), are: *Electronics Technology– core subjects*: Electronic Devices & Circuits, Electronics Workshop, Digital Electronics, Electronics Project (I & II), Industrial Electronics & Application, Microprocessor & Interfacing, Electronic Computer Aided Design (ECAD), Networks, Filters & Transmission Lines, Electronic Measurements & Measuring Instruments, Monochrome Television Engineering, Color Television & Video System, Communication Engineering, Servicing, Instrumentation & Process Control, Biomedical Engineering, Micro-controller & PLC, Communication Engineering, Computer Control Systems & Robotics, Advanced Communication Systems, Microwave, Radar and Navigation Aids.

Electrical Technology subjects: Electrical Engineering (electrical circuits; electrical machines; electrical power transmission, distribution and protection systems, etc.).

Information Technology subjects: Computer Operation & Word Processing, Spreadsheet Analysis, Database Management, Programming in C, Visual Programming, and Multimedia and Graphics.

The **related subjects** are (ibid):

Mathematics and natural science subjects: Mathematics, Applied Mathematics, and Science (Chemistry, Physics, Modern Physics).

Other related subjects: Languages (Bangla and English), Social Science (Civics, Economics, Bangladesh History & Culture), Physical Education (1 credit only), Book keeping & Accounting, Business Organization, Environmental Management, Business Communication, Industrial Management, Entrepreneurship, and Engineering Drawing.

For each subject credit points (C) and lesson hours are allocated. Each subject consists of two parts: a theoretical part (T) and a practical part (P). The theoretical part is taught in classrooms, the relevant practicals are conducted in laboratories.

It has been estimated that the total credit points allocated for the *Diploma-in-Engineering (Electronics Technology)* course are 166. On the basis of 16 working weeks per semester the total lesson hours available for the *Diploma-in-Engineering* programme have been calculated to 4800. The Pie Chart in Figure 4.1 shows the credit points and the lesson hours distribution for different sub-groups of subjects.

About 55.4% (42.8% + 5.4% + 7.2%) of the total credit points are allocated for technology based (domain specific) subjects. The next major percentage of credits is occupied by mathematics and natural science (18.7%). The rest are: 7.2% for management, book keeping, etc.; 12% for social science and laguages (Bengali and English); 3% for environmental management, physical education and engineering drawing. Only 6 credits (3.6% of the total credits) are allocated to industrial training. Here students spend 16 weeks, i.e. about 13% of the total estimated lesson hours, during the whole 4 years of the programme.

4.4.2. The Curriculum Content Analysis

The syllabus for the *Diploma-in-Engineering (Electronics Technology)* course is well documented. It is approximately 500 pages long. Figure 4.2 shows a page of the syllabus for a subject "Microcontroller and PLC". This subject is taught in the 6^{th} semester of the *Diploma-in-Engineering (Electronics Technology)* programme of BTEB.

It is noticeable that all the statements for 'AIMS' in this syllabus (Figure 4.2) begin with "To be able to Understand ...". Within the "*DETAIL DESCRIPTION* THEORY:" part of this particular subject (*Microcontroller and PLC*) 10 general objectives are specified. All of these general objec-

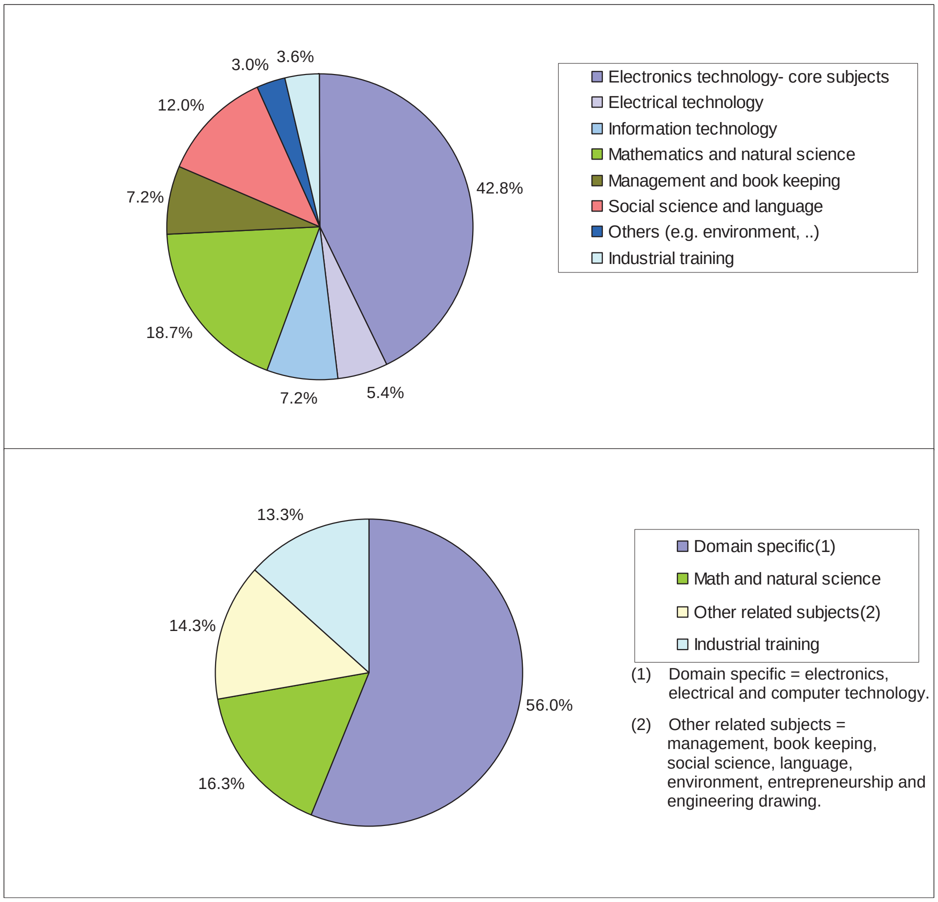


Figure 4.1.: Categories of subjects in the *Diploma-in-Engineering (Electronics Technology)* syllabus: according to allocated credit points (above), according to allocated lesson hours (below).

tives begin with the verb 'Understand', as given below (reproduced from the syllabus):

"1 Understand the basics of microcontroller."

"2 Understand the features of the 8051 microcontroller."

"3 Understand programming of the 8051 microcontroller."

"4 Understand the Timer and Counter programming in the 8051."

"5 Understand the interfacing of the 8051 microcontroller."

"6 Understand the real world interfacing ."

"7 Understand the programmable logic controller (PLC) and interfacing."

"8 Understand the extended PLC programming."

"9 Understand PLC communications."

"10 Understand the PLC special modules."

(*Diploma-in-Engineering (Electronics Technology)* 6^{th} semester syllabus.

Subject: "Microcontroller and PLC", p. 67 - 69.)

2865 MICROCONTROLLER AND PLC

T	P	C
2	3	3

AIMS

- To be able to Understand the basics of microcontroller.
- Understand the features of the 8051 microcontroller.
- Understand programming of the 8051 microcontroller.
- Understand the Timer and Counter programming in the 8051.
- Understand the interfacing of the 8051 microcontroller.
- Understand the real world interfacing
- Understand the programmable logic controller (PLC) and interfacing.
- Understand the extended PLC programming.
- Understand PLC communications.
- Understand the PLC special modules.

SHORT DESCRIPTION

The 8051 microcontrollers, architecture, instructions, addressing modes, programming, the 8051 serial communication, the interrupts programming, the real world interfacing. Programmable logic controller and interfacing; Extended PLC programming; PLC communications; PLC special module; Industrial control systems.

DETAIL DESCRIPTION

THEORY:

1 Understand the basics of microcontroller.

1.1 Define microprocessor, microcomputer, microcontroller and PLC.
1.2 Describe the basic the basic building blocks of a microcontroller device in general.
1.3 Know the history and development in microcontrollers.
1.4 Distinguish embedded and external memory devices, CISC and RISC processors.
1.5 Mention Harvard and Von Neumann architecture.
1.6 Identify different commercial microcontroller.
1.7 State the importance of microcontroller in control system.

2 Understand the features of the 8051 microcontroller.

2.1 List the salient features of the 8051
2.2 Describe the architecture of the 8051.
2.3 Describe the general purpose registers of .8051.
2.4 Explain Special function registers (SFR) and program status word (PSW)

Figure 4.2.: A part of the *Diploma-in-Engineering (Electronics Technology)* syllabus (printed from original). (Subject: “Microcontroller and PLC”, 6th Semester, p. 67. T = Theory, P = Practical lesson hours and C = Credit points)

Generally, a curriculum, particularly the TVET curriculum, includes content (tasks) with different levels of learning objectives [(Bloom et al., 1956); (Anderson & Krathwohl, 2001); (Marzano & Kendall, 2007, p. 15)]. Different types of tasks serve different learning objectives at different cognitive process levels. In order to examine how the learning objectives of the Diploma level curriculum in Bangladesh have been constructed, the following text presents a detailed analysis of the curriculum content of a particular subject.

In detail description of the theory part of “Microcontroller and PLC”, for example, 71 specific learning objectives (learning items) are given (ibid.). Each specific objective is constructed with one or more action verbs. They are listed in Table 4.1. The term *Describe* has been used 29 times and the next verb *Explain* occurs 13 time (Table 4.1). The others are (in descending order) *Program* (7), *Interface* (7), *Mention* (5), *Input* and run (5), Use (4), *Prepare* (3), *Connect* (3), *Identify* (2) *Code* (2) *Define* (1), *Know* (1), *Distinguish* (1), and *State* (1).

Table 4.1.: The frequency of verbs used in the syllabus for "Microcontroller and PLC".

Verb	N	Verb	N	Verb	N
Describe	29	Explain	13	Program	7
Interface	7	Mention	5	Input and run	5
Use	4	Prepare	3	Connect	3
Identify	2	Code	2	Define	1
Know	1	Distinguish	1	State	1

Some examples of frequently used verbs that relate to the function of the cognitive process level of *Apply*[2] of the Bloom's Taxonomy; are: apply, develop, implement, translate, use, operate, interpret, demonstrate, practice, calculate, show, exhibit, etc. (Bloom et al., 1956). Verbs that relate to the fucntion of the cognitive process level "Understand" are: describe, differentiate, distinguish, discuss, explain, express, illustrate, identify, interpret, mention, recognize, review, etc. and the verbs that relate to the cognitive process level of *Remember* are: define, identify, know, list, name, recognize state, repeat, record, et cetera. The verb summarised in Table 4.1 from the curriculum shows that majority of the learning objectives are of level *Remember* and / or *Understand*. That mean, the Diploma-in-Engineering curriculum / syllabus is mainly theory oriented. This observation has been made not only on the basis of the usage of verbs, but also on the basis of the content of the syllabus.

The subject "Microcontroller and PLC", just described above, includes fourteen items for practical work / laboratory experiments. They are shown in Figure 4.3.

It has been found, with some exceptions, that many of these recommended laboratory assignments / practicals can not be categorised as application oriented problems and / or excercises[3]. For example, from Practical number 1 to 5, students are asked to input and run assembly lan-

[2]The cognitive process category *Apply* is the ability to use learned material, or to implement them in concrete and new situations.

[3]An application oriented task simulates (more or less) real world situation, where students can apply the knowledge of subjects taught in classroom or learned from books.

Practical:

1. Input and run assembly language program to perform arithmetic and logical operation using 8051 microcontroller trainer.
2. Input and run assembly language program to compute 1's or 2's complement of binary number using 8051 microcontroller trainer.
3. Input and run assembly language program using 8051 microcontroller trainer for data transfer between I/O and memory with different I/O techniques.
4. Input and run assembly language program using 8051 microcontroller trainer to implement the branching and looping structures.
5. Input and run assembly language program to using 8051 microcontroller trainer to implement the subroutine operation.
6. Create source file, .OBJ file and list file using assembler.
7. Write the executable program to microcontroller IC using IC writer.
8. Prepare a microcontroller and construct a circuit to interface an LCD.
9. Prepare a microcontroller and construct a circuit for Speed control of DC motor.
10. Study the architecture and operation PLC.
11. Show ability to connect input devices with PLC.
12. Show ability to connect output devices with PLC.
13. Show ability to configure of PLC to PLC/PC.
14. Show ability to prepare PLC program.

Figure 4.3.: A list of practicals from the subject: "Microcontroller and PLC". (*Diploma-in-Engg.(Electronics Technology) Syllabus*. 6^{th} Semester, p. 70)

Practical:

1. Input and run assembly language program to perform arithmetic and logical operation using 8085 / 8086 / 8088 / 6800 microprocessor trainer.
2. Input and run assembly language program to compute 1's and 2's complement of binary number using 8085 / 8086 / 8088 / 6800 microprocessor trainer.
3. Input and run assembly language using 8085 / 8086 / 8088 / 6800 microprocessor trainer for data transfer between I/O and memory with different I/O technique.
4. Input and run assembly language using 8085 / 8086 / 8088 / 6800 microprocessor trainer to implement the branching and looping structures.
5. Input and run assembly language 8085 / 8086 / 8088 / 6800 microprocessor trainer to implement the subroutine operation.

Figure 4.4.: A list of practicals from the subject: "Microprocessor and Interfacing I". (*Diploma-in-Engg.(Electronics Technology)* Syllabus. 4^{th} Semester, p. 44)

guage programs:

- to perform arithmetic and logical operation,
- to compute 1's or 2's complement of binary number,
- to transfer data between I/O and memory,
- to implement the branching and looping structures, and
- to implement the subroutine operation.

The majority of the tasks listed above tend to be theoretical because no concrete situations are mentioned where they find their application. Moreover, exactly the same tasks have been recommended for practicals in the subject "Microprocessor & Interfacing I" in 4^{th} semester, except the type of core processor (Practical number 1 to 5 in Figure 4.3 and 4.4).

The *Practical numbers 6* to *7* are just typing the 'source code' and issuing two commands by pressing the correct buttons. However, the *Practical numbers 8* and *9* are workplace relevant examples. But they are incomplete, in the sense that it is not specified clearly whether students should programme the systems and test some functions. The *Practical numbers 10* to *14* are too abstract and incomplete.

Nevertheless, some specific objectives mentioned in this subject are found to be relevant in practice. They are listed in Table 4.2.

Table 4.2.: A list of specific objectives found to be workplace relevant in the subject "Microcontroller and PLC". (Diploma-in-Engg. (Electronics Technology) 6th Semester Syllabus, p. 67 - 69.)

4.3	Program the 8051 timer to generate time delay.
4.5	Program the 8051 counter as event counter.
5.2	Write code in assembly language program to use the ports for input or output.
5.5	Program the 8051 for serial data transfer.
5.9	Program the 8051 using interrupts.
6.4	Program an LCD by sending data or commands to it from the 8051.
6.5	Interface temperature sensor to the 8051.
6.7	Interface the 8051 with a stepper motor and
6.8	Code 8051 programs to control and operate it.
6.11	Explain how to use both on-chip and off-chip memory with the 8051.

As found from the analysis of the syllabus for "Microcontrollers and PLC[4]", students may not acquire necessary technical competences in this area during their education and training for day to day situations in commence.

As seen in the *Diploma-in-Engineering (Electronics Technology)* Syllabus (5^{th} Semester, p. 21), the recommended practicals/ laboratory experiments in the subject "Microprocessor & Interfacing

[4] "Microcontroller and PLC" is taught at 6th Semester. It is one of the core subjects for Diploma-in-Engineering (Electronics Technology).

II" taught in 5^{th} semester are :

1. Study the hardware of microprocessor based single board computer (16 bit/ 32 bit/ 64 bit).
2. Make simple program by using MC 68000 microprocessor instruction set and test them on MC 68000 trainer.
3. Make simple program by using intel 80286 / 80386/ 80486 / Pentium microprocessor instruction set and test them on respective trainer.
4. Study the interfacing system of different peripheral device to the Intel Microprocessor.

The aims, as described in the syllabus, for delevering this subject are: "to provide the students with an opportunity to acquire knowledge, skills and attitude in the area of microprocessor and interfacing with special emphasis on: features of 16, 32 & 64 bit microprocessors; memory interface, I/O interface; DMA controller; coprocessor and bus interface; Pentium processor" (*Diploma-in-Engineering (Electronics Technology)* Syllabus. 5^{th} Semester, p. 19). The time allocated to this subject is as follows: 32 lessos hours for the theory part and 48 lesson hours for the practicals[5]. The author is in doubt how students can acquire knowledge, skills, and attitude in such area (16, 32 & 64 bit microprocessor and Pentium processor; memory interface, I/O interface; DMA controller; coprocessor and bus interface) within this given time. It may only be possible theoretically, but not in practice. Moreover, the practicals listed above are by no means workplace relevant. The author does not assume that an employer is going to ask his/her Electronics Technician (Diploma Engineer) to write a programme using MC 68000, Intel 80286/ 80386/ 80486/ Pentium microprocessor instruction set. This knowledge and skills maybe useful for someone who is going to write a 'compiler'. This is not the task of an electronic technician.

The author has reviewed the syllabuses for other subjects of the electronics technology course and found more or less the same picture.

In summary, the Diploma-in-Engineering (Electronic Technology) curriculum focuses mainly on theoretical knowledge at the cognitive level 'reproduction' and 're-organization', and not on the practical relevant skills at the 'transfer' level. Unless teachers practice tasks that are real world relevant, students will learn mainly the basic theories and principles, because in full-time school based TVET system the classroom and the laboratory are the main learning places, the effect of 12-week (plus 4 weeks in polytechnic) industrial training may not influence significantly in developing their practical competences.

---

[5]On an average one semester consists of 16 weeks.

4.4.3. Analysis of the Question Papers for the Final Examination

As mentioned earlier the *Diploma-in-Engineering* programme is divided into 8 semesters. BTEB conducts the final examination at the end of each semester.

In this piece of work the question papers of the final examinations for the last three years have been analyzed and classified according to Anderson & Krathwohl Taxonomy for Learning, Teaching, and Assessing. Figure 4.5 shows a question paper - a measuring instrument for student performance - prepared by BTEB, as sample copy (in original). A translated copy of this question paper is given in Figure 4.6.

In general, 3 hours time are allocated to answer the questions in a question paper with 50 marks, like the one shown in Figure 4.5 or 4.6. The questions are organised into three groups. The author found during the analysis of the question papers that, the first group, Group A, contains 20% of the total marks in a subject. It includes ten very short objective type questions. These question items assess mainly students' knowledge in the cognitive process category Remember (the 'Reproduction' level). The second group, Group B, contains 40% of the total marks and includes ten short (objective) type questions. Items in this group are mainly used, as the author has found while studied, to assess students' knowledge in the cognitive process category *Remember* and to some extent the knowledge in category *Understand* (the 're-organisation' level). The third group, Group C, contains 40% of the total marks. It consists of five descriptive type questions. A student can choose any four out of these five items in this group. This group measures also mainly the theoretical knowledge at the level 'reproduction' and 're-organisation'.

For example, none of the items in Group C assesses students' knowledge in cognitive process category *Apply* (the 'transfer' level in the examination question paper for 'Microcontroller and PLC', shown in Figure 4.6 (translated English version) or 4.5 (the original Bangla version), . Similarly, no item from other two groups could be classified in the category *Apply*. In other words, items in these categories assess students' competences in the category *Remember* (reproduction) and in the category *Understand* (re-organisation) at the highest level, not at level *Apply*.

The overall findings of the analysis are presented in the Pie Chart (Figure 4.7). It shows the items (in percentage) classified into three different categories: *Remember* (Level 1), *Understand* (Level 2) and *Apply* (Level 3) of the cognitive process dimension[6] and in two different types of knowledge: the declarative (the factual and conceptual) and the procedural knowledge. It is to be noted that some items demand knowledge in two or more categories of knowledge and levels of cognitive process. They are classified to a category that dominates the items.

[6]The other three higher level categories are not considered here. The items in these categories, if any,

বাংলাদেশ কারিগরি শিক্ষা বোর্ড, ঢাকা

ডিপ্লোমা-ইন-ইঞ্জিনিয়ারিং শিক্ষাক্রম

২য়, ৪র্থ, ৬ষ্ঠ ও ৮ম পর্ব সমাপনী পরীক্ষা-২০০৯

টেকনোলজি ঃ ইলেকট্রনিক্স

বিষয় ঃ মাইক্রোকন্ট্রোলার অ্যান্ড পি.এল.সি

বিষয় কোড ঃ ২৮৬৫

সময় ঃ ৩ ঘন্টা পূর্ণমান ঃ ৫০

ক ও খ-বিভাগের সকল এবং গ-বিভাগের যে কোন ৪ (চার)টি প্রশ্নের উত্তর দাও।

ক-বিভাগ (মান ঃ ১০×১=১০)

১। মাইক্রোকন্ট্রোলার বলতে কী বুঝায়?
২। ডাটা পয়েন্টারের কাজ কী?
৩। অ্যাসেম্বলার ডিরেকটিভ্‌স্ বলতে কী বুঝায়?
৪। ইভেন্ট কাউন্টার এর কাজ কী?
৫। ইন্টারাপ্ট প্রাইওরিটি বলতে কী বুঝায়?
৬। মাইক্রোকন্ট্রোলারের সাথে এল.সিডি এর ইন্টারফেসিং করা হয় কেন?
৭। সার্কিট প্রটেকশন ডিভাইস এর দু'টি ব্যবহারিক ক্ষেত্র উল্লেখ কর।
৮। পি.এল.সি প্রোগ্রামিং ল্যাংগুয়েজ বলতে কী বুঝায়?
৯। পি.এল.সি এর নাম্বার সিস্টেম ব্যবহারের সুবিধা কী?
১০। পি.এল.সি সিস্টেমে নেটওয়ার্ক মডিউল কী?

খ-বিভাগ (মান ঃ ১০×২=২০)

১১। ৮০৫১ মাইক্রোকন্ট্রোলার এর গুরুত্বপূর্ণ বৈশিষ্ট্যগুলো লেখ।
১২। ৮০৫১ মাইক্রোকন্ট্রোলার এর কাউন্টার এর কাজ বর্ণনা কর।
১৩। ৮০৫১ মাইক্রোকন্ট্রোলার এর ইন্টারাপ্টগুলোর কার্যাবলী সংক্ষেপে লেখ।
১৪। পি.এল.সি প্রোগ্রামিং ল্যাংগুয়েজে ব্যবহৃত প্রতীকগুলো অংকন করে নাম লেখ।
১৫। হার্ভার্ড এবং ভন নিউম্যান প্রবর্তিত মাইক্রোকন্ট্রোলার এর আর্কিটেকচার অংকন কর।
১৬। ৮০৫১ মাইক্রোকন্ট্রোলার এর স্পেশাল ফাংশন রেজিস্টার (SFR) এর কাজ সংক্ষেপে লেখ।
১৭। ৮০৫১ মাইক্রোকন্ট্রোলার এর ইনস্ট্রাকশন কয় প্রকার ও কী কী? এদের নাম লেখ।
১৮। ৮০৫১ মাইক্রোকন্ট্রোলার এর টাইমারের সংক্ষেপে বর্ণনা দাও।
১৯। পি.এলসি কন্ট্রোল সিস্টেমে ব্যবহৃত বিভিন্ন মোডগুলোর নাম লেখ।
২০ কম্বিনেশন এবং সিকুয়েন্সিয়াল লজিক এর মাঝে পার্থক্য লেখ।

গ-বিভাগ (মান ঃ ৪×৫=২০)

২১। ৮০৫১ মাইক্রোকন্ট্রোলার এর পিন ডায়াগ্রাম অংকন করে পিনের কাজ বর্ণনা কর।
২২। ৮০৫১ মাইক্রোকন্ট্রোলার এর অ্যাড্রেসিং মোড কয় প্রকার ও কী কী, বর্ণনা কর।
২৩। ৮০৫১ মাইক্রোকন্ট্রোলার এর সাথে এনালগ টু-ডিজিটাল কনভার্টার (ADC) এর ইন্টারফেসিং চিত্রসহ বর্ণনা কর।
২৪ পি.এল.সি এর আর্কিটেকচার অংকন করে সংক্ষেপে বর্ণনা কর।
২৫। পি.এল.সি এর মেমোরি এর অর্গানাইজেশনের চিত্র অংকন করে বর্ণনা কর।

Figure 4.5.: A question paper for the 6th semester final examination in subject 'Microcontroller and PLC' in Bangladesh.

It has been found that the question items assess mainly students' theoretical knowledge (knowledge reproduction). That means, the question items are constructed in such a way that they rarely demand 'transfer' level skills. For example, in the category *Declarative knowledge* (*the*

---

have been put into the category *Apply*.

Bangladesh Technical Education Board, Dhaka
Diploma-in-Engineering Course
2^{nd}, 4^{th}, 6^{th} and 8^{th} Semester Final Examination – 2009
Technology: Electronics
Subject: Microcontroller and PLC
Subject Code: 2865

Time: 3 hours   Full marks: 50

Answer all questions from Group A and B and any four questions from Group C

Group A (Marks: 10 x 1 = 10)

1. What is meant by microcontroller?
2. What is the function of the data pointer?
3. What is meant by assembler directives?
4. What is the function of the event counter?
5. What is meant by interrupt priority?
6. Why is LCD interfaced with microcontroller?
7. Name two application fields of circuit protection device.
8. What is meant by PLC programming language?
9. What is the advantage of using the number system of PLC?
10. What is the network module in a PLC system?

Group B (Marks: 10 x 2 = 20)

11. Write the important characteristics of the 8051 microcontroller.
12. Describe the function of the counter of the 8051 microcontroller.
13. Write briefly the functions of interrupts of the 8051 microcontroller.
14. Draw and write the name of symbols used in PLC programming language.
15. Draw the "Harvard architecture'' and the "von Neumann architecture'' of the microcontroller.
16. Write briefly the functions of special function registers (SFR) of the 8051 microcontroller.
17. How many types of instructions has the 8051 microcontroller? Write their names.
18. Describe briefly the timer of the 8051 microcontroller.
19. Write the names of different modes used in PLC control system.
20. Write the difference between the combinational and the sequential logic.

Group C (Marks: 5 x 4 = 20)

21. Draw the pin diagram of the 8051 microcontroller and describe the function of each pin.
22. How many kinds of addressing modes has the 8051 microcontroller?
23. Describe in figures the interfacing of analogue to digital converter (ADC) with the 8051 microcontroller.
24. Draw the architecture of a PLC and describe it briefly.
25. Draw the picture of memory organisation of the memory of a PLC and describe it.

Figure 4.6.: A translated copy of the question paper for the 6th semester final examination in subject 'Microcontroller and PLC' in Bangladesh shown in Figure 4.5.

Factual and Conceptual knowledge), it has been found that about half (48.1%) of the total items in the final examination question paper can be classified under the category *Remember* (Level 1). Almost all of the rest items (42.6%) are under the category *Understand* (Level 2), and only 0.8%, are under the category *Apply* (Level 3). The total items in the category *Procedural knowledge* are divided into three different cognitive process categories, namely *Remember*, *Understand* and *Apply*. The percentage of these three categories are 0.8, 2.9, and 4.3, respectively. Irrespective of the

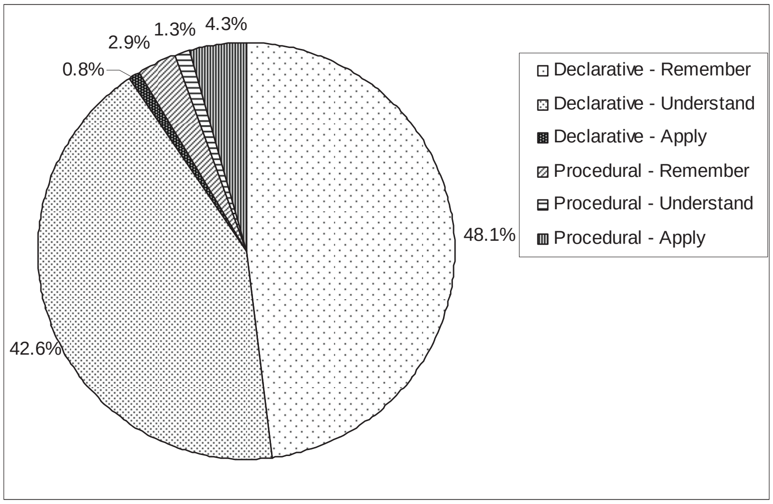


Figure 4.7.: The percentage of items in the final examination question paper (classified according to Anderson & Krathwohl taxonomy) in Bangladesh.

knowledge category (the Bloom's Taxonomy) the percentage of items in the category *Remember*, *Understand* and *Apply* are 51, 43.9 and 5.1, respectively.

In brief, the author finds in his analysis that the examination question papers in Bangladesh are constructed to assess mainly theoretical knowledge in the category *Remember* and in the category *Understand*. Assessment of student performance in the category *Apply* is only undertaken in a few cases. If the items are classified according to Bloom's (1956) taxonomy, the items on an average for the cognitive process category *Remember*, the category *Understand*, and the category *Apply* are 51.0%, 43.9%, and 5.1%, respectively.

4.5. Content Analysis of the German Apprenticeship Training Curriculum

In the dual system of vocational education and training (VET) in Germany, the education and training in recognized occupations take place at vocational schools and at enterprises. The federal government regulates the training at industries through training regulations. The Standing Conference of the Ministers of Education and Cultural Affairs of the Länder (KMK) in the Federal Republic of Germany, develops a framework curriculum for vocational subjects that are taught at vocational schools (Berufschulen).

The framework curriculum for an occupation consists of a basic education for a group of occupations in a field or area (berufsfeldbreite Grundbildung) and a technical specialisation for a particular occupation (fachspezifische Ausbildung: Stufe I and II).

The framework curricula are built in principle on the level of secondary school. Since the vocational school, however, is attended by young people and adults, who have usually different educational qualification, learning ability, cultural background and experiences from their respective training companies, the framework curricula are designed so open that they allow adaptation to meet the individual needs of teaching in the Länder (the states). Therefore, the Länder can adopt the framework curriculum of the Standing Conference directly and without change or implement their own curriculum KMK (2007). In the second case, the technical contents and time duration must satisfy the framework curriculum.

The framework curricula describe the mission of the vocational schools to educate their trainees and also principles of didactic (KMK, 2008). They are structured according to learning fields (Lernfelder) and are developed by teachers on the basis of the guidelines for the development of framework curriculum of the Standing Conference (ibid.).

4.5.1. The Contents of the German Apprenticeship Training Curriculum

For the teaching at vocational schools in the areas of economic and social studies and business-technical training occupations, the Standing Conference of the Ministers of Education and Cultural Affairs of the Länder has agreed on elements that are coordinated with the federal government and the social partners. Curricula for general education at vocational schools are generally developed by individual Länder. The following Figure shows the content distribution (in terms of lesson hours) of the curriculum for the occupation “Electronics Technician (Devices and Systems)” in Baden-Württemberg.

The calculation was made as follows (in lesson hours): domain specific professional expertise (technical content, including engineering / applied mathematics) 1020 (recommended lesson hours in framework curriculum), general subjects (languages, social studies, business / economic competence) 360, others (religion, physical education, etc.) 180, industrial training 4504 (calculated over three and a half years excluding public holidays (10), holidays (30), etc).

As mentioned above, the framework curricula are structured based on learning fields. The learning fields comprise the objectives, the learning contents and recommended lesson hours. The following table (Table 4.3) shows an overview of the learning fields for the vocational education and training occupation of “Electronic Technician (Devices and Systems)”.

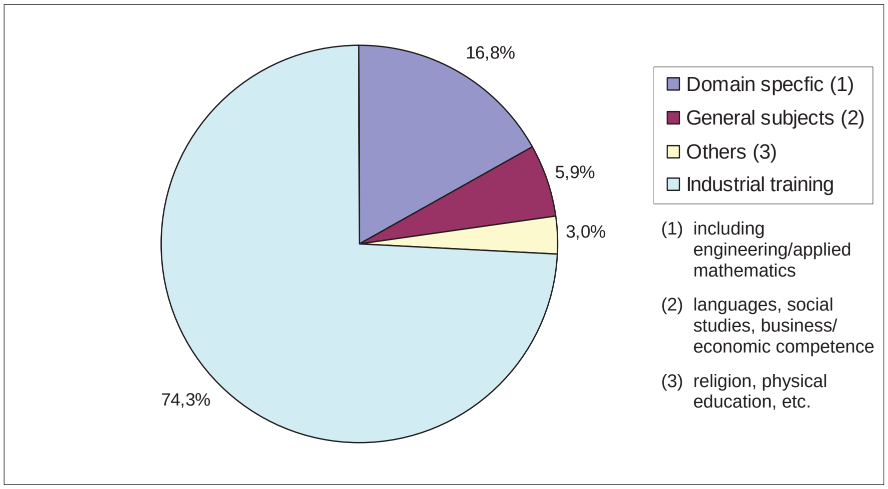


Figure 4.8.: The lesson hour distribution of the curriculum for “Electronics Technician (Devices and Systems)” in Baden-Württemberg, Germany.

The learning fields number 1 to 4 in Table 4.3 provide trainees with the basic skills and attitudes (berufsfeldbreite Grundbildung) and, therefore, they are common to the occupations in the occupational family “Electrical and Electronic Technology” that includes the occupations: electronics technician for aerospace systems, automation technology, building and infrastructure systems, energy and building technology, electronics technician for devices and systems, industrial engineering, information and communication technology, and machines and drives technology.

The learning fields number 5 to 13 vary from occupation to occupation. For the training occupation “Electronic Technician (Devices and Systems)”, a detailed list of contents with their objectives are given in KMK (2008).

In the following section, the examination question papers will be analyzed as part of the curriculum content analysis. Because, *firstly*, the student assessment is one of the vital components of a curriculum and, *secondly*, the curriculum for the German apprenticeship training is very flexible, i.e. contents are not specified explicitly. Therefore, instead of analyzing the curriculum content, the examination question papers over the last three years will be analyzed.

4.5.2. Analysis of the Question Papers for Apprenticeship Training Examination

The apprenticeship training in the dual system takes place at two different places: the vocational school and the enterprise. The assessment of trainees for the practical part of the examination is conducted at the enterprise. The following text describes the assessment procedure of

Table 4.3.: An Overview of the learning fields for the occupation of *Electronic Technician (Devices and Systems)*. (KMK, 2008)

Learning fields		Recommended lesson hours			
Nr.		1. Year	2. Year	3. Year	4. Year
1	Analyze electrical systems and verify their functions	80			
2	Plan and implement electrical installations	80			
3	Analyze and customize programmable logic controllers (PLC)	80			
4	Install, manage and service information technology (IT) systems	80			
5	realize electrical power supply for devices and systems and ensure their safety		80		
6	Design, manufacture and test of electronic devices and circuits for equipment and systems		60		
7	Configuration of hard- and software for electronic devices		80		
8	Manufacture and test of electronic devices, systems and equipment		60		
9	Maintain, inspect and service the devices and systems			100	
10	Set up the manufacturing facilities			80	
11	Setup and use of test systems			100	
12	Plan and realisation of devices and systems				80
13	Maintain and service the manufacturing and test systems				60
	Sum (total 1020 lesson hours)	320	280	280	140

the trainees in vocational schools; the student assessment process in enterprises is not covered in this study.

At vocational schools there are two examinations: the intermediate examination (at the end of one and a half years) and the the final examination (at the end of two and a half years or three and a half years). The final examination is conducted by the chamber of commerce and industry (Industrie- und Handelskammer). The types of question papers may differ among the states (the Länder) in Germany. In Baden-Württemberg the final examination is taken in three consecutive days. On the first day, the examination for general subjects (social studies, economics and languages) takes place. The examinations for the technical subjects, namely, *Occupational Theory I (Berufstheorie I)* and *Occupational Theory II (Berufstheorie II)* take place on the following two consecutive days.

The Organisation of question papers

In the examination for technical subjects, trainees' knowledge and skills in the areas - "Function and System Analysis" (Time 120 minutes) and "System Design" (Time 120 minutes) - are tested.

The tasks in the examination question papers are practical situation oriented. Mostly, at the beginning of a question paper, a project from a learning situation is described. Then it is followed by a set of questions, mainly regarding this project. The question items are organized again according to topics. That is, several question items are posed under a certain topic.

For example, Figure 4.9 shows a part of a question paper that begins with a project description, namely "Strom von der Sonne" (Electricity from the Sun).

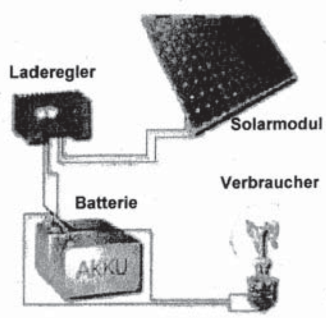
Abschlussprüfung Winter 2008/09 von Berufsschule und Wirtschaft (gewerblicher Bereich) in Baden-Württemberg	FA 205
Berufstheorie I	Elektroniker/-in für Geräte und Systeme Systemelektroniker/-in

Projekt: Strom von der Sonne

Projektbeschreibung:

Sie arbeiten in einer Firma, die Solaranlagen plant, verkauft und montiert. Ein Kunde möchte sein Ferienhaus, für das es keinen Zugang zum Stromnetz der Energieversorger gibt, mit einer sogenannten Inselanlage ausstatten.

Den prinzipiellen Aufbau einer Inselanlage zeigt die nebenstehende Graphik.



Inselanlagen benötigen neben dem Solarmodul einen Speicher, damit in der Nacht und in strahlungsärmeren Zeiten die erforderliche Energie zur Verfügung steht. Um den Akkumulator vor Schäden durch Über- bzw. Tiefentladung zu schützen, ist die Installation eines Ladereglers zwischen Solargenerator und Akkumulator notwendig.

Gleichstromtaugliche Geräte, z. B. aus dem Automobilzubehörsektor, können direkt betrieben werden sofern die Betriebsspannung übereinstimmt.

Sollen Verbraucher betrieben werden, die Wechselspannung benötigen, ist zusätzlich noch ein Wechselrichter erforderlich.

Figure 4.9.: A question paper (part only) begins with a project description. (Abschussprüfung Winter 2008/09 'Berufstheorie I' for Eectronic Technician (Devices and Systems), p. 2).

This project "Strom von der Sonne" in the question paper "Winter 2008/09 *Berufstheorie I* for Electronic Technician (Devices and Systems)", presented in Figure 4.9, is followed then by a group of question items. The group *Function and System Analysis 1 (FS 1) Electricity Generation in a Solar Cell*, for example, includes seven question items, the group *Function and System Anal-*

ysis 2 (FS 2) Estimation of Energy Demand includes 6 question items, the group *FS 3 Over Voltage Protection* includes seven question items. Similarly, in the test area of System Design (SE), three such groups of question items have been found, namely, SE 1 Low Voltage Monitoring, SE 2 Inverter, and SE 3 Cable Resistance. The construction of the question paper *Berufstheorie II* is more or less the same.

The Construction of question items

The test items are found to be practical relevant, in almost all cases. This is, of course, one of the objectives of the learning field oriented curriculum for the initial vocational training in Germany. The questions are open type. The answers to the questions may range from short to long. A sample of question items from the test area of *Function and System Analysis* is shown in Figure 4.10. In order to facilitate the examinees and to improve the comprehensibility of the questions, an incomplete circuit diagram was provided in Appendix, as shown in Figure 4.11. This group of questions (FS 3) asks the examinees:

1. explain the reason why the accumulator must be disconnected from the solar module after a certain voltage level is reached;
2. add a protective circuit with a diode into the given incomplete circuit in the appendix so that the accumulator can not discharge itself through the solar module, for example, when the solar module supplies no voltage during the dark;
3. determine the voltage of the accumulator that causes the relay to drop and disconnect the accumulator from the solar module;
4. calculate the value of the biasing resistor for the switching transistor;
5. write down the reason why the switching transistor should be over biased;
6. add a freewheeling diode with the relays in order to minimize the peak inductive voltage.
7. add a circuit with LED that should glow during the accumulator charging time.

That means, in order to answer to the questions, a trainee is to use, and in most cases, to transfer the knowledge in various areas in the field of electronic technology. For example, the solar cell, the accumulator charging and discharging, the transistor biasing, the operation modes of transistor, working principle and application of rectifiers/ diodes, the operation principle of relay, the accumulator protection mechanism, and so on. Thus trainees learn how to build an electronic system or part of a system.

FS 3 Überspannungsschutz (Anlage 4(5))

Gegeben ist die in Anlage 4(5) dargestellte Schaltung, die dazu dient zu hohe Spannungen vom Solarmodul fern zu halten.

3.1 Erläutern Sie den Grund, warum die leitende Verbindung zwischen Solarmodul und Akkumulator ab einer bestimmten Akkuspannung aufgetrennt wird.

3.2 Versehen Sie die Schaltung mit einer Diode so, dass sich der Akkumulator nicht über das Solarmodul entladen kann, wenn dieses z. B. bei Dunkelheit keine Spannung liefert.

3.3 Berechnen Sie den Wert der Akkumulatorspannung, der dazu führt, dass das Relais abfällt und die Verbindung zwischen Solarmodul und Energiespeicher öffnet.
Die Schwellspannung der Diode von Aufgabe 3.2 bleibt unberücksichtigt.

3.4 Der Transistor K_2 arbeitet im Schalterbetrieb.
Berechnen Sie R_5 so, dass der Transistor dreifach übersteuert wird.

3.5 Nennen Sie den Grund dafür, dass als Schalter eingesetzte Transistoren in der Regel übersteuert werden.

3.6 Um Induktionsspannungsspitzen zu unterdrücken soll das Relais mit einer Freilaufdiode versehen werden.
Zeichnen Sie die Freilaufdiode in die Schaltung ein.

3.7 Versehen Sie die Schaltung mit einer Meldeeinrichtung (Leuchtdiode) so, dass das Ansprechen des Überspannungsschutzes signalisiert wird. Die Leuchtdiode soll aufhören zu leuchten, wenn der Ladevorgang unterbrochen wird.

Figure 4.10.: A group of question items regarding the project shown in Figure 4.9.

The question papers of the final examination for the last three years have been studied. It has been found that in most of the cases the question items are constructed in such a way that they are practical relevant and they demand a higher level (above the level 'reproduction') of cognitive knowledge and skills from the trainees.

The questions/ items in the final examination for the last three years have been analyzed and classified according to Anderson & Krathwohl Taxonommy for Learning, Teaching, and Assessing. Figure 4.12 shows the items (in percentage) classified in three different categories, *Remember* (Level 1), *Understand* (Level 2) and *Apply* (Level 3) of the cognitive process dimension[7]. The quantity of items in each category is presented (in percentage) in Figure 4.12.

It has been found that only 7.5% of the total items in the final examination question paper can be classified under the category *Remember* (Level 1), whereas 23.7%, and 32.6% are under the category *Understand* (Level 2), and the category *Apply* (Level 3), respectively, in the category *Factual and Conceptual knowledge* (the *Declarative knowledge*). In the category *Procedural knowledge* the percentage of total items in three different cognitive process categories are 0.4, 2.6, and 33.3, respectively.

[7] The other three higher level dimensions are not considered here. The items in these categories, if any, have been put into the category *Apply*. Furthermore, some items demand knowledge in two or more categories of knowledge and levels of cognitive process. They are classified to a category that dominates the items.

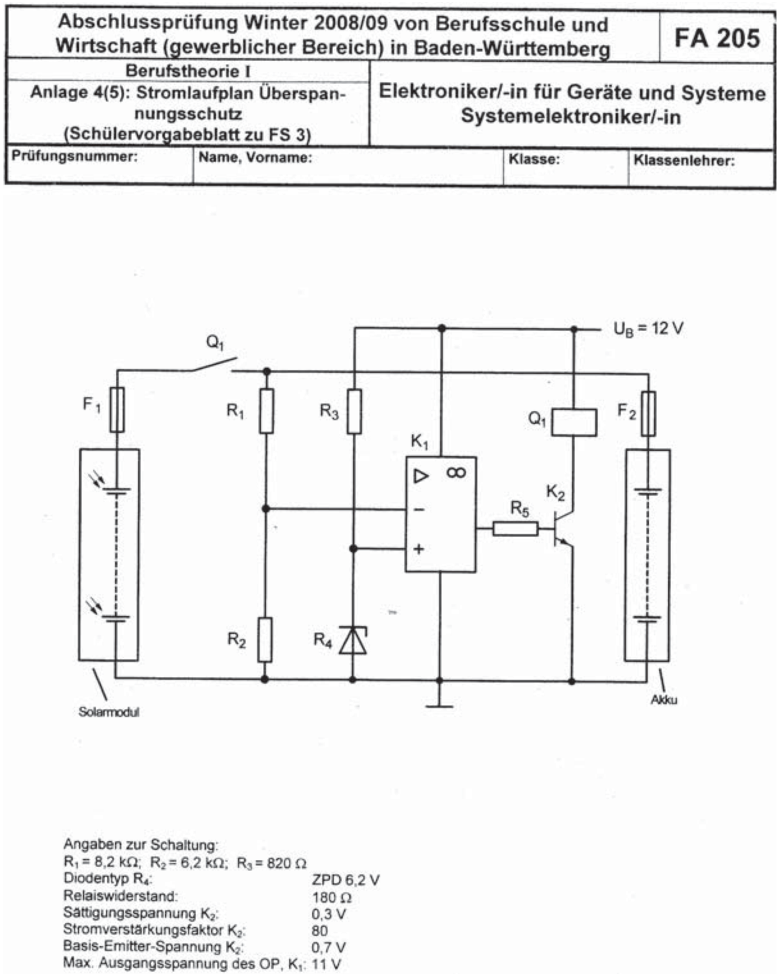


Figure 4.11.: A supplement for the question items in FS3 given in Figure 4.10.

On an average, 65.8% of the question items are of category *Apply*, 26.3% are of category *Understand*, and only 7.9% are of category *Remember*, according to Bloom's (1956) taxonomy. This data indicates in summary that:

- the German curriculum that includes the examination as well, focuses mainly on application oriented tasks;
- *Procedural knowledge* is supported by including a good number of question items (33.3%) in this category of knowledge;
- in the final examination trainees are tested mainly whether they can transfer the knowledge, rather than testing if they can reproduce what is taught.[8]

Thus it can be concluded that this kind of test supports the curriculum objectives.

[8]This approach is supported by providing the trainees with most of the factual knowledge/ information required to produce 'new' knowledge. For example supply of table book, data sheets and supplementary circuit diagrams, et cetera.

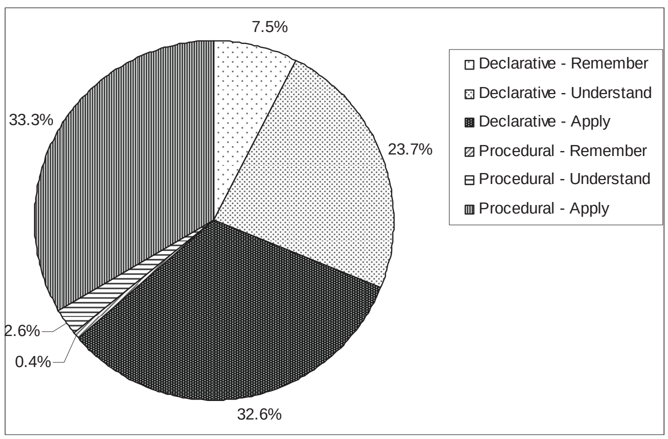


Figure 4.12.: The percentage of items in the final examination question papers in Germany (classified according to Anderson & Krathwohl taxonomy).

5. Survey of Student Learning Achievement

5.1. The Target Groups for the Survey

In this work the technical competence of the students of polytechnic institutes in Bangladesh and the trainees of vocational schools in in Germany are measured. Graduates of the polytechnic institutes and vocational schools generally work as the middle-level workforce. The number of students/ trainees (sample size) in each group is intended to be approximately 160. The following subsections describe both groups.

5.1.1. Polytechnic Students in Bangladesh

This group consists of polytechnic students in Bangladesh who are at the end of the *Four-Year Diploma-in-Engineering (Electronics Technology)* course. That is, the participants of this test are the 4th year students. However, some of them have just taken the 8th (the last) semester final examination of 2009. In Bangladesh the Diploma level students are in the average between 16 and 18 years old at the beginning of this programme.

More recently, the Bangladesh National Technical and Vocational Qualification Framework (TVQF) has been proposed (Moore, 2009). The *Diploma-in-Engineering* qualification is recommended at Level 6 of TVQF (Appendix D.1). "It is the premier and the highest TVET qualification in the technical education sector" (Moore, 2009, p. 13).

The class size of the *Diploma-in-Engineering* course in Bangladesh is about 40 students. This test includes five polytechnic institutes in order to fulfill the intended group size (160 students) as well as considering other factors, e.g. location (capital city, remote area), type of administration (publicly or privately run).

5.1.2. Apprenticeship Trainees in Germany

Apprenticeship trainees in Germany undergo a three-year to three-and-a-half-year vocational education programme in the dual system: at vocational schools and at enterprises. An initial study of the curricula for this initial apprenticeship training programme shows that the occupation of *Electronic Technician (Devices and Systems)* and *Electronic Technician (Industrial Engineering)* closely correspond to the Bangladeshi group, the *Diploma in Engineering (Electronics Technology)*. The apprenticeship training qualification in Germany is at ISCED LEVEL 3B (ReferNet-Germany, 2009, p. 37). An ISCED LEVEL 3B qualification (i.e. initial VET training) encompasses the medium level of proficiency (VET-LSA, 2009, p. 3). These and also other vocational qualifications have not yet been referenced to the levels of a *National Qualifications Framework*. The *German Qualifications Framework* is still under development (ReferNet-Germany, 2009, p. 29). The German apprenticeship trainees are at average between 16 and 18 years old at the beginning of the education and training.

The intended size of this group is also 160. This test includes trainees from seven vocational schools in Baden-Württemberg, Germany.

5.2. The Test and the Test Instrument

5.2.1. Test Planning and Design Requirements

The objective of the test is to measure the student learning achievement (the occupational competence). In fact, there are many views, meanings, and components of occupational competence (Section 2.2). Since the technical knowledge / competence is the strongest predictor of the ability to solve technical problems [(Nickolaus et al., 2005); (Nickolaus et al., 2006)] and it is very time consuming work to measure all the components of occupational competence considering all aspects, therefore only the technical competence will be measured under this work.

The **time duration** of the test is one of the important factors to be fixed before constructing the test instrument. The test processing time was fixed to 60 minutes, plus 10 to 15 minutes time for students sitting in the classroom and for motivation to take the test. At the end of the test 5 to 10 minutes time is also necessary for collecting the answer sheet and for student's verbal feedback. This total test duration (c. 85 minutes) fits well in a double lesson (usually 90 minutes) and was favourable for organizational reasons. The second reason to limit the test duration is that the student may not hold the motivation when the test-time is too long. A shorter duration might not be able to capture sufficient information over the whole curriculum.

The **language** of the questionnaire and answer is another important factor. All students (Bangladeshi and German) should be presented the same questions (vollständige Aufgabendarbietung; (Lienert & Raatz, 1994, p. 79)), however, it has been planned that the language of the questions for

Bangladeshi students will be English and a translated Bengali version of the questionnaire will be supplemented. The students will answer either in English or in *Bangla*. The language of questions and answers will be German for the trainees in Germany.

It is common that in Germany students use a handbook / an Engineers' data reference book (Tabellenbuch) in the classroom and also in the examination. But in Bangladesh it is not the case. Here a student must recall all the factual information he / she requires to solve a problem in the examination, if not supplied as data sheet together with a question paper. The questionnaire was designed in such a way that a student is able to answer to the questions without such reference book. Necessary data sheet were supplied.

As this work concentrates on a particular technology, the electronics technology, the test should capture students' electro-technical knowledge and competences in core areas and also in areas of specialisation, which are to be mastered by the learners in principle and represent the basis for the development of vocational competence. Furthermore, as the main objective of this survey is to measure students' competenceies in workplace relevant situations, the emphasis was to design questions predominantly as "practical" and "real-world" situation tasks.

It has been proved that domain-specific knowledge, e.g. knowledge about constituent elements of the upcoming learning fields, is usually the largest contributor to the explanation of variance of the learning success, or to the predicted performance of the future development of individuals (Dochy, 1992; with reference to Knöll, 2007, p. 128). Therefore, the test must integrate enough easy questions. In addition, some general test elements covering related / other fields of learing should be included which is a prerequisite to cope with future electro-technical problems. These include basic mathematical skills, for example. There should be some test elements that have middle level requirements. Some test elements should demand relatively higher level knowledge that can only be solved by very good students.

5.2.2. A Brief Description of the Test Instrument

The test instrument used for the survey is not a standardised one, but self-designed. The questions included in the questionnaire cover the whole curriculum content. However, to make the test sophisticated enough (well-balanced over the whole curriculum content) without breaking the routine time frame, the questions were picked only from selected areas of importance in the field of electronic technology (in Germany, Elektroniker / in - Geräte und Systeme sowie Systemelektriniker / in, und Elektroniker / in - Betriebstechnik). Questions were chosen that correspond to tasks in real occupational situation, in order to measure the students' competencies acquired at the end of the course which they will require in their subsequent occupational activities.

The test consists of a combination of multiple choice and open questions. The multiple choice questions are designed so that false answers are ‘attractive’ distractors, i.e. they are plausible or to be taken seriously, although they should be clearly wrong. There can be more than one correct answer in the case of the “multiple-choice” question type. For each false choice there is a negative (-) mark, to discourage random choice. Most of the tasks are of the open question type where student write their answer on the question paper. The complete set of the tasks is given in the appendix.

As mentioned in the above section, the tasks used in the test should measure students’ competencies both in declarative and procedural knowledge domain. In order to test the students’ competencies on the *Remember, Understand, Apply* and *Analyze* level, the tasks (the assessment items) have been chosen from various levels of the cognitive process dimension. Expert teachers were consulted during the test construction phase. A pilot test was carried out with a small group of student in Germany. On the basis of the test results and according to the expert advice, some tasks were re-defined, rearranged, explained for better and clearer comprehensibility. The time duration of the test was closely observed during the pilot test phase and the number of tasks was adjusted according to a predetermined test time. This procedure ensures the optimal time usage given for the test.

Relevant pictures, tables and data-sheets were included in order to make the test attractive to the students. Furthermore, the test begins with the simplest task and then gradually complexer tasks are presented. To keep the motivation and concentration of the student throughout the test, there is a mix of simple and relatively complex tasks throughout the questionnaire.

5.2.3. Description of Tasks and Their Classification

It has been considered at the design phase that the test instrument should measure students’ factual, conceptual and procedural knowledge at the cognitive process levels *Remember* through to *Apply*. In some cases it measures the higher level knowledge as well.

Factual knowledge is knowledge that is basic to specific disciplines. This dimension refers to essential facts, terminology, details or elements students must know or be familiar with in order to understand a discipline or to solve any of the problems in it.
Conceptual Knowledge includes knowledge of classifications and categories, knowledge of prin-

ciples, generalizations, and knowledge of theories, models, or structures pertinent to a particular disciplinary area.
Procedural Knowledge refers to information or knowledge that helps students to do something specific to a discipline, subject, area of study. It also refers to methods of inquiry, very specific or finite skills, algorithms, techniques, and particular methodologies. The task types that check procedural knowledge must demand the successful applying and combining of procedures, approaches and / or strategies as a mandatory.

Remembering task type should be solved by the students in the simplest case by recognising or recalling, in much the same form as they were taught, from the long term memory. To assess student learning in this category the student was given a group of recognition or recalling tasks (see table 5.1), for example recalling the nominal data transfer speed of a Fast Ethernet network communication or recognising the functions (or truth tables) of basic digital logic gates, naming parts of a microcomputer and its peripheral components / interfaces, et cetera.

When the primary goal of instruction is to promote retention, the focus is on objectives that emphasize *Remember*. When the goal of instruction is to promote transfer, however, the focus shifts to the other five cognitive processes, *Understand* through *Create*.

Students understand when they build connections between the "*new*" knowledge to be gained and their prior knowledge. More specifically, the incoming knowledge is integrated with existing schemas and cognitive frameworks. Since concepts are the building blocks for these schemas and frameworks, *Conceptual knowledge* provides a basis for understanding. The cognitive processes in the category of *Understand* include interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining.

Apply involves using procedures to perform exercises or solve problems. The *Apply* category consists of two cognitive processes: *executing* – when the task is an exercise (familiar) – and *implementing* – when the task is a problem (unfamiliar). *Implementing* requires some degree of understanding of the problem as well as of the solution procedure. In the case of *implementing*, then, to *understand conceptual knowledge* is a prerequisite to being able to *apply procedural knowledge*.

As mentioned earlier the test instrument includes 16 tasks. A task consists of one or more items. A description of all the tasks and the assessment objectives for each are given below. In this description some tasks are presented as examples. The complete questionnaire is given in Appendix A. Since two or more types of knowledge and cognitive process categories are often necessary to accomplish a task, it is to be considered which type of knowledge and cognitive process category account for the central difficulty of the task in order to place it in an appropriate cell in the Taxonomy Table.

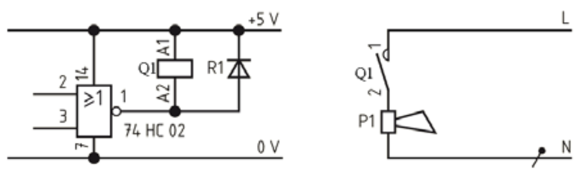
Task 1: Task 1 is chosen from the area of basic electro-technique. Logic gates, relays and contactors are the basic elements for the electronic technology course. They are the building blocks for major electronic control circuits. In this task, the circuit in the Figure below is such a small control circuit using a NOR logic gate and a relay with a single contact.

Electronics and Relays/Contactors

Task 1

To isolate the main circuit from the control circuit (galvanic isolation) relays and contactors are often used. Figure 1 shows the relay Q1 (relay-coil A1/A2 and relay contact 1/2) and the logic module 74HC02 (a NOR-logic connection). The control circuit should be able to control the horn (P1) on the main circuit.

Q1.1 Complete the following truth table.



Truth Table for 74HC02

Inputs		Outputs
2	3	1
0	0	
0	1	
1	0	
1	1	

Figure 1: Relay circuit with separate control and main circuit

Q1.2 Mark the correct answer(s)

- ☐ The horn will sound if the output 1 is in the high state (logical 1).
- ☐ The horn will sound if the output 1 is in the low state (logical 0)..
- ☐ The horn will sound always independent to the state of output 1, because it is on a separate circuit.
- ☐ The horn will never sound, because it is on a separate circuit.

There are two questions on this task. Question Q1.1 is posed to assess students' knowledge in the cognitive process category *Remember*. A student should be able to answer this question by recalling the truth tables of the OR gate and the NOT gate, as they were presented in the textbook or as they were taught, then, combining these two in order to find the truth table of the NOR gate (74HC02). Some students may answer this question by simply recalling the truth table of the NOR gate as in text book or as taught directly. Therefore, this item is placed under the cognitive process category *Remember* of factual and conceptual knowledge, according to the Anderson & Krathwohl (2001) Taxonomy.

The second question Q1.2, on the other hand, requires the conception of basic laws of electricity and knowledge of the principle of relay operation and of galvanic separation of electric circuits. It is categorised as conceptual knowledge under the cognitive process level *Understand*. To answer this question correctly a student must form a clear conception in his / her mind that relates the presence or absence of potential difference, the current flow, and the relay operation. The most critical point to be noticed here is that the relay will operate (close its normally open (NO) contact) when the output 1 of the NOR gate of 74HC02 is low (logical 0), not high (logical 1), as there is a $+5V$ supply on the other end of the relay coil. In general, student is used to using high potential, also greater than 0, to switch on a load. Students who will answer this question by simply recalling or recognising from their long time memory, will, certainly, make mistake.

Such types of electronic circuits are often used in electronic controls where the control circuit (low voltage side) must be separated from the main power circuit (relatively high voltage side).

Task 2: Task 2 was chosen from the area of motor control using relays and contactors. Basic knowledge in electrical circuits, relays and motor control techniques are required to solve this task. To view this task please see Appendix A– Task 2. A brief explanation of the operation method of the control circuit is also supplied. The objective is to measure if a student is able to interpret the given information and estimate the consequence of occurrence of a fault in the circuit. Four plausible answers were supplied. Students should choose the correct answer(s). This task is, therefore, classified under the cognitive process category *Understand* of the knowledge type *Conceptual*.

Task 3: Task 3 assesses students' basic knowledge in the subject area of programmable logic controllers (PLCs). It consists of three items, Q3.1, Q3.2 and Q3.3. In the first item Q3.1, two types of memory functions along with examples of applications are presented. Knowledge about these basic memory functions is essential for a technician who will work with PLC. These memory functions are generally taught separately, but a student must be able to differentiate between them and use the right one where it is appropriate. To assess student knowledge in this area, the students were asked to assign the applications given in a list to the appropriate memory function. The second item Q3.2 tests students' knowledge in the PLC programming language Instruction List (IL). To make the question easy, multiple plausible answers were supplied. The third item Q3.3 test students' knowledge in safety functionalities. This task is classified as the cognitive category *Understand* of the *Conceptual* knowledge.

Task 4: Sensors are used almost everywhere. Task 4 tests students' ability to select the right sensor for a particular application. This task includes two questions, Q4.1 and Q4.2. In question Q4.1, a list of commonly used sensors and a list of applications are supplied to the students. From the given list of sensors they are supposed to select the one appropriate for a particular application given in another list (item matching). It is assumed that these types of sensors and their applications are generally taught. It requires the cognitive process *Recognising*. In Question Q4.2, on the other hand, students give the name of the sensor where its functions are defined in the question.

Both questions Q4.1 and Q4.2 are classified as cognitive category *Remember* of conceptual knowledge.

Task 5: Information and communication technologies (ICT) are increasingly utilized almost everywhere today. Technical skills in this field are strongly demanded and considered as key competencies. By this task students' knowledge in the ICT field is assessed. The task is: "adding a new PC to an existing network". Assessment was made to examine if students can buy necessary hardware, know the name of the network protocol commonly used, and the command that is necessary to accomplish the task. The task 5 can be seen in Appendix A

This task is classified as *Factual knowledge* at the *Remember* level.

Task 6: Flipflop is a one-bit memory element and is the building block for memory in electronic system. Knowledge of flipflop is essential for students of electronic technology. This tiny electronic element is used not only in constructing mega-size hardware memory, but its functionality is also used in PLC programming in order to store bit type information.

The simple RS flip-flop (also commonly known as SR flip-flop) has two inputs (R for reset and S for set) and one output (Q, sometimes also /Q). Normally, when the R and S inputs are both low (the storage mode) it keeps the previous state of Q, that is, it works as single-bit memory. If S is pulsed high while R is held low, then the Q output is forced high, and stays high even after S returns low; similarly, if R is pulsed high while S is held low, then the Q output is forced low, and stays low even after R returns low. When both inputs are high, then the output is not defined (race condition).

Although the learning objective is not just the reproduction of the functions of the RS flip-flop, but its use. However, flip-flops are such basic elements of digital systems that the student should be able to recall or recognise their functions when required for applications. The Questions Q6.1 and Q6.2 of Task 6 test if students have learned the functionality of the RS flip-flop as taught or in text book. Therefore, both questions are classified as the category *Remember* of *Factual* knowledge.

Task 7: Task 7 requires understanding the principle of the Wheatstone bridge, sensors and different functionalities of operational amplifier. To answer Questions Q7.1 and Q7.2, a student must have the basic understanding of the situation here and the purpose (the measurement of very low voltage) of using this operational amplifier. This task is classified as factual and conceptual knowledge (Anderson & Krathwohl (2001)). To answer Question Q7.1 a student must understand the situation and the circuit, so it is classified as the knowledge level of *Understand*. Question Q7.2 is placed at level *Remember* in the kognitive process dimension of Anderson & Krathwohl Taxonomy, since a student can answer this question by recalling (or recognising) the specific circuit of an operational amplifier for the given function.

Task 7

Figure 6 shows a Wheatstone bridge circuit with an operational amplifier (OpAmp). B1 and B2 are resistances of passive sensors, for example strain-gauge sensors. Using the Wheatstone bridge the changes of these resistances are captured as electrical voltage and fed to the operational amplifier.

Q7.1 As what function is the operational amplifier used here? Mark (A), (B), (C) or (D).

(A) Comparator (B) Differentiator
(C) Summing amplifier (D) Differential amplifier

Q7.2 Complete the wiring for the operational amplifier shown below (with necessary electrical components) so that it functions as what you have chosen in Q7.1).

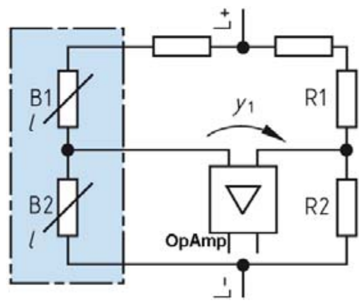
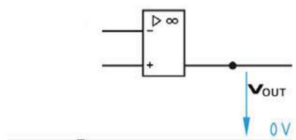


Figure 6: Wheatstone Bridge Circuit



This is a very common circuit used in measuring technique for acquiring the physical quantities (i.e. pressure, thermal radiation, temperature, humidity, sound, brightness, or acceleration) as electrical quantity. The operational amplifier amplifies the very low voltage to a useful level for further processing (often by microcontrollers in measuring technique, control systems, et cetera).

Task 8: This one is a problem type task, not an exercise and taken from subject area of basic electronics and electronic systems. This task is relatively complex compared to the other tasks in this test. This task requires a very good understanding of a transistor as a switching element. A student must be able to apply this understanding in order to control the relay output. Knowledge about relay, diode and potential divider is also a prerequisite.

To help students to solve this problem, the task is divided into small parts, Q8.1 to Q8.6. Question Q8.1 concerns a simple potential divider. This circuit provides, ca. +5V DC, potential and is fed to a microcontroller to check the switching status of the normally closed (NC) contact 11/12 of the relay Q1. Question Q8.2 checks if a student understands the functionality of the circuit and can document its input/output relationship, as in the given truth table. Question Q8.3 tests student comprehension capability of what happens (the voltage and current wave shapes) inside the circuit when a particular input bit pattern (signal) is applied. Question Q8.4 demands a conception of the relationship between mechanical and electrical energy and the variation of electrical energy with pulse width. Question Q8.5 requires only recalling relevant vocabulary from memory. For example, some vocabulary of terms and features generally used in microprocessor-based systems. But knowledge about microcontroller is not mandatory to solve other items of this task. Question Q8.6 requires the cognitive process *Understand* in the knowledge category of *Conception*.

However, to solve this problem a student must be using mainly the higher level cognitive processes, such as *Apply* and / or *Analyse* in the knowledge categories of *Factual* and *Conceptual* knowledge.

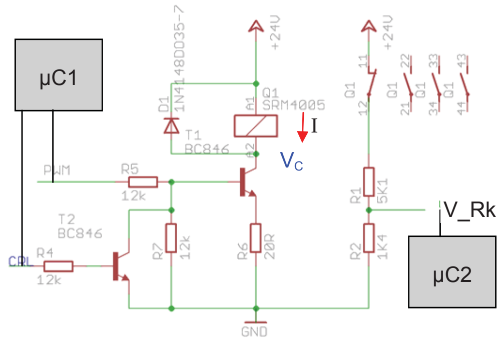
Task 8

A customer requires an electronic device. The device must have safety relay outputs. The schematic in Figure 7 shows a possible implementation of such an output. The forcibly guided relay Q1 (SRM4005) is controlled by the microcontroller µC1 and verified for its correct functionality by the second microcontroller µC2.

Q8.1 Calculate the potential V_Rk with respect to ground GND
i) when the normally closed (NC) contact 11/12 of Q1 is closed

and ii) when normally closed (NC) contact 11/12 of Q1 is open.

Q8.2 Complete the truth table (Use the TTL logic level (0 or 1) for V_Rk).



Truth Table		
Inputs		Output
CRL	PWM	V_Rk
0	0	
0	1	
1	0	
1	1	

Figure 7: Relay Control and Verification

Q8.3 The micro-controller µC1 monitors other safety arrangements, for example a protecting door. Assume that the protecting door is closed, the µC1 writes a logic 0 on the control pin CRL, i.e. CRL = 0. Complete the following timing diagram for the collector potential V_C of the transistor T1 and the relay coil current I_R, when the µC1 applies a periodic pulse width modulated signal on the control pin PWM.

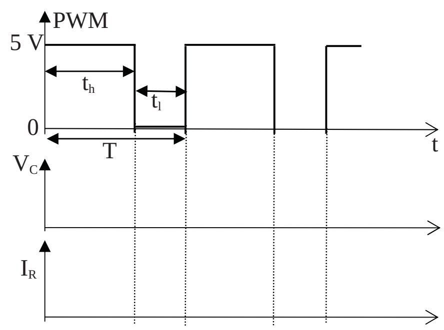


Figure 7-1: Timing diagram for V_C and I_R

Q8.4 Will the relay operate and remain steady or follow the signal PWM (disturbance!)? Justify your answer (hints: the effect of the time duration of t_h and t_l).

Q8.5 Name a bus over which the µC2 can send the status of the relay to the µC1

Q8.6 What function has the diode D1 in this circuit (Figure 7)?

The electronic circuit shown in Task 8 is one part of an electronic system that is used in automation and machine safety.

Task 9: This task requires mainly students' skills to read data sheets and some knowledge of serial communication techniques. It is categorized as *Procedural* knowledge at level *Apply* of the Anderson & Krathwohl Taxonomy. This task is to implement a practical circuit that is often used in developing microcontroller based systems.

Task 9.
To communicate between a microcontroller and a PC you will need to design a serial interface. Figure 8 shows the datasheet of a RS-232 driver/receiver. It is required for interfacing the serial port of the PC (RS-232 Standard) with the serial port of the microcontroller (TTL/CMOS standard).

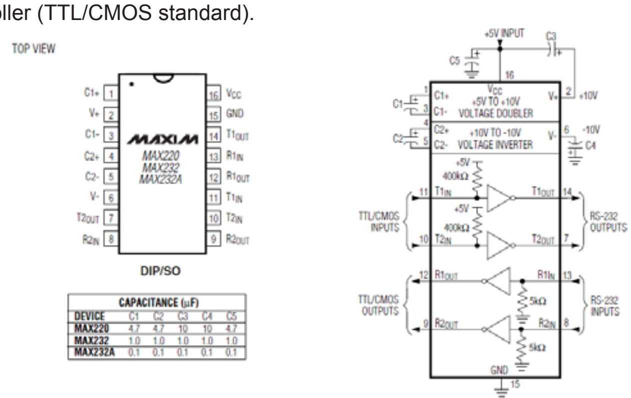


Figure 8: Datasheet of MAX220/MAX232/MAX232A (Pin Configuration and Typical Operating Circuit).

Q9.1 Complete the prepared circuit diagram in Figure 9 that connects the chip MAX232 to the serial port of the microcontroller (RXD, TXD) and to the 9-pin sub-D connector.

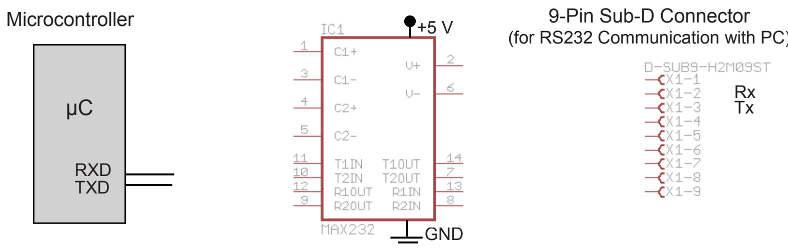


Figure 9: Circuit diagram for serial interface

Q9.2 Wire the chip MAX232 with appropriate value of capacitors required for it. (See also Datasheet in Figure 8)

Task 10: *C* is a general-purpose computer programming language. Today, it is the widely used programming language for developing portable application software and firmware for microprocessor-based devices and systems. This taks tests if students can read and understand *C code*[1]. The code given in Task 10 implements a basic logic gate (AND, OR, NOT). A student should understand the code in order to choose the correct logic function and the correct bit numbers. Therefore, this task is put under the category *Understand* of conceptual knowledge.

[1]Since *C* is relatively low-level (close to hardware) a student with knowledge in Assembly programming language may also be able to read this *C code*.

Task 10
The following source code implements a logic module in C.

```
typedef struct
{   unsigned    char    Input_Sigs;     /* bit7 … bit1 bit0 */
    unsigned    char    Output_Sigs;    /* bit7 … bit1 bit0 */
}LogicModule;

LogicModule   Lm;

if ((Lm.Input _Sigs & 0x0F) == 0x0F )

  { Lm.Output _Sigs = Lm.Output _Sigs | 0x10;}
else      {Lm.Output _Sigs = Lm.Output _Sigs & 0xEF;}
```

Q10.1 Name the basic logic function (OR, AND, or EXOR) programmed above.

Q10.2 Write which bit(s) of *Input _Sigs* and *Output* _Sigs are used for this logic module.

Task 11: This task examines if students know about the modern bus systems used in industrial communication. Students are presented three commonly used industrial network buses (CAN, ASI and PROFIBUS DP). They are asked to write the full name for each abbreviated name of the bus and choose from a list (supplied with the question) an appropriate application for it. This task is classified in the category of *Remember* since it demands only the cognitive process *Recognize*.

Task 12 concerns the calculation of the size of an uninterruptible power supply (UPS) unit for a server room. A list of electrical devices is provided. In part one of the task (Q12.1) students should identify the devices from the list which must remain in operation during power failure and needs to be backed up by the UPS, so that a “power failure notice” can be sent automatically from the server.

In part two of the task (Q12.2) students should apply only a basic mathematical procedure (addition, multiplication and division) to calculate the correct size of the UPS, where they should consider a power reserve of 25% of the new UPS. This item (Q12.2) assesses mainly students’ procedural knowledge at the level of *Apply*. The other item (Q12.1) assesses conceptual knowledge (a basic conception of an IT network system) at the level of *Understand*.

Task 13 demands knowledge of characteristics of DC motors with respect to supply voltage. Skills in calculating the average voltage from a pulse-wave signal is also necessary to solve this problem. Furthermore, this task demands basic mathematical skills. But knowledge of pulse-width modulation technique is not necessary here. This task is categorized as *Procedural knowledge* at the level of *Apply* of the Anderson & Krathwohl Taxonomy.

Electrical Motors/Drives

Task 13

To drive a mobile robot DC motors with built-in gears are used. The motor data are N = 100 rpm at a voltage of V =+12 V.

Q13.1 The motors are operated from a battery voltage of Vb = +9 V. Calculate the speed of the motors when operating with the battery.

Q13.2 The speed of the motors is controlled using a pulse width modulated (PWM) signal. The motors are supplied by a voltage shown in figure 10. The frequency of the signal is f = 100 Hz. The motors should run with a speed of N = 10 rpm. Determine the pulse duration t_i of V_{PWM}.

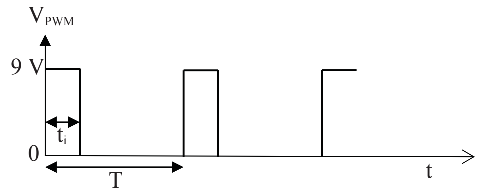


Figure 10: Periodic pulse with modulated control voltage

Task 14: The *Emergency STOP* switch is used in almost all electrical installations. This task assesses students' knowledge of using this switch with a particular example from the area of machine safety. The first part (Q14.1) tests if students know the *Emergency STOP* switch at all, whereas in the second part (Q14.2) of the task students are assessed for conceptual knowledge at the level of *Understand*. In both cases students choose the correct answer from the plausible (multiple choice) items (Appendix A– Task 14).

Task 15: Electrical technicians install devices often by consulting technical/ instruction manuals. In this task (Appendix Task 15) an instruction manual for using a device for an electrical installation (Emergency STOP) and an incomplete circuit diagram are provided to the students. Students are asked to complete the diagram according to certain instructions.

To solve this task a student does not need to recall information from his/her memory. But it demands students' ability to understand technical manuals and extract the appropriate information and apply it to a particular occupational situation. This task assess students' skills at the *Apply* level.

Task 16:

Small Controllers/ PLC

Task 16

You have got a contract to develop a control programme for a construction lift (Figure 13). As a controlling device you will be using a small controller (or a PLC). The lift basket should be able to move between the two limit switches S2 at the top and S4 at the bottom automatically. When the 'Stop' button is pressed, the lift should stop immediately. If the `Up'/ `Down' button is pressed, the drive should continue its journey automatically. A three-phase motor (M) is used as drive. The motor is switched on/off via contactors Q1 (Up) and Q2 (Down). A protective interlocking and a locking latch in the programme of the controller must be used to prevent the motor from simultaneous right-left run. When the motor is overloaded the lift must be stopped by the over current relay (F1) immediately.

Q16 Draw the functional block diagram (FBD) or ladder diagram (LD) for this control programme. Use the allocation table and the connection layout *(Figure 14)* of the controller.

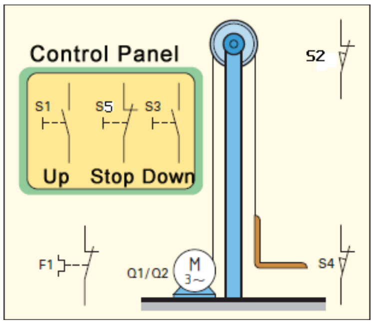


Figure 13: A construction lift and control panel.

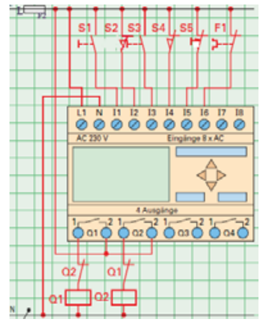


Figure 14: Terminal connection layout.

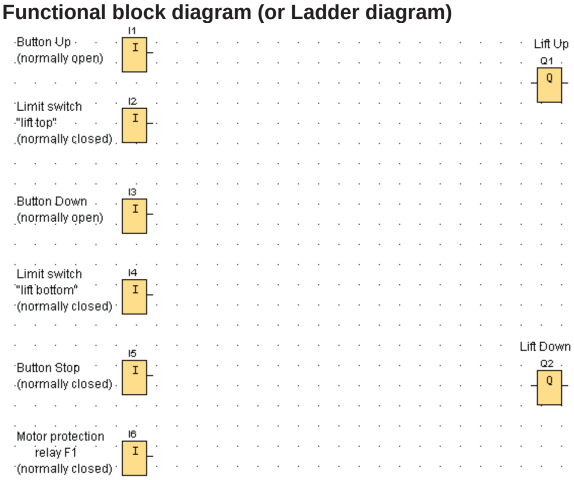
Allocation table

1 → Input and outputs of the controller

2 → Operating resources

1	2	Description
I1	S1	Button lift Up (normally open)
I2	S2	Limit switch lift `top' (normally closed)
I3	S3	Button lift Down (normally open)
I4	S4	Limit switch lift `bottom' (normally closed)
I5	S5	Button lift Stop (normally closed)
I6	F1	Motor protection relay (normally closed)
Q 1	Q1	Main contactor, lift Up
Q 2	Q2	Main contactor, lift Down

Functional block diagram (or Ladder diagram)



Programmable logic controller (PLC) is generally a compulsory subject for electronic technology. In Germany it is taught in the first year of the programme for all occupations in the field of electrical and electronic technology. This subject is taught again in the final year of the programme as specialisation. For the *Diploma-in-Engieering* course in Bangladesh this subject has been introduced very recently.

Task 16 tests the student's ability to solve a real world problem using a small controller or PLC. They are supposed to know the programming technique using the graphical programming language as well as a clear conception of the problem and the logic to be used to implement the task. This task is classified as *Conceptual* knowledge at the level of *Apply* in the Anderson &

Krathwohl Taxonomy for learning, teaching and assessing.

Table 5.1 shows the complete classification of tasks used in the competency measurement test.

Table 5.1.: The taxonomy of the tasks used for the competency test. The number in bracket shows the allocated point(s). (Total 100 points.)

The Knowledge Dimension	The Cognitive Process Dimension					
	1. Remember	2. Understand	3. Apply	4. Analyse	5. Evaluate	6. Create
A. Factual and B. Conceptual Knowledge	Task01-Q1.1 (2) Task04-Q4 (8) Task05-Q5 (6.5) Task06-Q6 (3) Task07-Q7.2 (4) Task08-Q8.5 (1) Task11-Q11 (6) Task14-Q14.1 (1.5)	Task01-Q1.2 (1) Task02-Q2 (2) Task03-Q3 (8) Task07-Q7.1 (2) Task08-Q8.4 (2) Task08-Q8.6 (1) Task10-Q10 (3) Task12-Q12.1 (1.5) Task14-Q14.2 (2)	Task08-Q8.1 (3) Task08-Q8.2 (4) Task08-Q8.3 (4) Task09-Q9.1 (4) Task16-Q16 (14)			
	Total points = 32	Total points = 22.5	Total points = 29			
C. Procedural Knowledge			Task09-Q9.2 (2.5) Task12-Q12.2 (3) Task13-Q13 (6) Task15-Q15 (5)			
			Total points = 16.5			
D. Metacognitive						

5.3. Validity of the Test Questions

The *validity* of a measure is how well it fulfills the function for which it is being measured. The validity of a test can be viewed as the accuracy of specified inferences made from its score. During the process of test validation, one examines the relationships among test scores, other empirical data, and logical considerations (Hopkins et al. (1990)). A test possesses many validities; it may be highly valid for one purpose but not for others.

To validate the competency test, the test questions were presented to the experts/ teachers. These teachers/ experts have a long teaching and/or industry experience in the field of electronic technology. They have assessed the test questions on the basis of a five-point answer scale (Figure 5.1). They were asked if the subject content/ topic regarding a particular task was taught in the classroom, the industrial training or if it is not in the syllabus. Furthermore, this questionnaire asks: the probability that the students can solve the task, the degree of complexity, comprehensibility and the workplace relevancy for the occupation *Diploma Engineer (Electronic Technology)*.

Figure 5.1 shows the questionnaire which was used to assess the validity of the test by experts/ teachers. From fifteen (15) experts/ teachers, ten (10) are from Germany and five (5) from Bangladesh. Two of the Bangladeshi experts are trainers at Technical Teachers' Training College, Dhaka.

Assessment of the tasks of the technical competency test
by teacher/ expert in the field of electrical & electronic engineering

Task 1

Were the contents/topics regarding this task taught in classroom or in industrial attachment/ training?	Yes, about .....% / No, because ☐ not in syllabus ☐ short time ☐ …………………
The probability that the students can solve the task	very low ☐ ☐ ☐ ☐ ☐ very high
The degree of complexity of the task	very low ☐ ☐ ☐ ☐ ☐ very high
The degree of comprehensibility of the task	very low ☐ ☐ ☐ ☐ ☐ very high
Industry/ workplace (real-world situation) relevance	very low ☐ ☐ ☐ ☐ ☐ very high

Figure 5.1.: The questionnaire for assessing the tasks used for the competency test

Thus the **content validity** was estimated from the data given by teachers/ experts (Figure 5.2).

The content related to Tasks 5, 9 and 15 were taught only about 25% in Bangladesh. Task 5 is related to "integrating a PC to an existing network", Task 9 is "to make a connection between a PC and a microcontroller using a datasheet" and Task 15 is "installing a safety device using a technical manual". These tasks can be seen in Appendix A. Teachers in Bangladesh told the author that these types of tasks are neither taught in class nor practiced in the laboratory.

Task 10 is related to the "C Programming language" and this language is not taught at vocational schools in Germany. Instead, mainly *Assembly* language is taught here. Therefore, this task is rated with below 20% by German teachers. In Bangladesh, both C and Assembly language are taught.

The **criterion related validity** such as workplace relevance was estimated from the data given by the same experts/ teachers, as presented in Figure 5.3. On an average, almost all the tasks

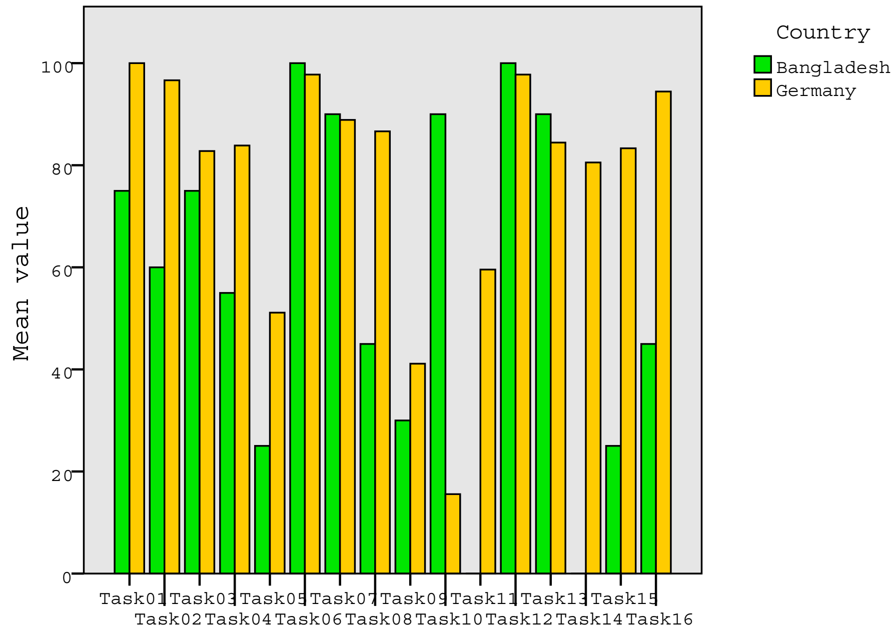


Figure 5.2.: The percentage of task related content taught in class or in enterprise

were termed as practical relevant, where about 75% of the tasks were graded with, nearly above or below, 4 and the rest of the tasks were graded with 3.5 on a five-point scale shown in Figure 5.1. Similarly the degree of complexity of Task 1 to Task 16 is given in Figure 5.4. The statistical data of the teachers' assessment for the content validity, the 'praxis relevance', the comprehensibility and the complexity of the tasks are given in Appendix B.

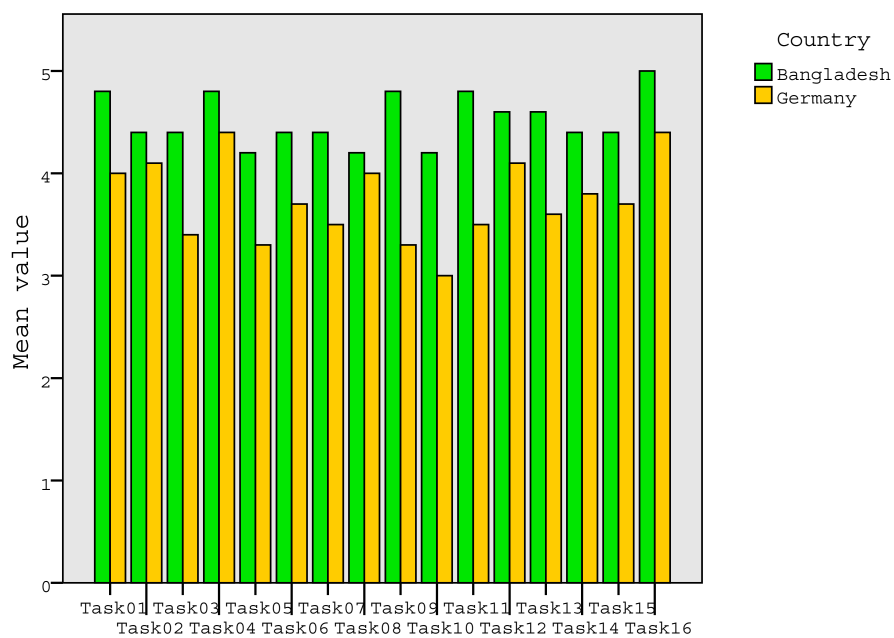


Figure 5.3.: Practical relevancy of the tasks assessed by experts/ teachers.

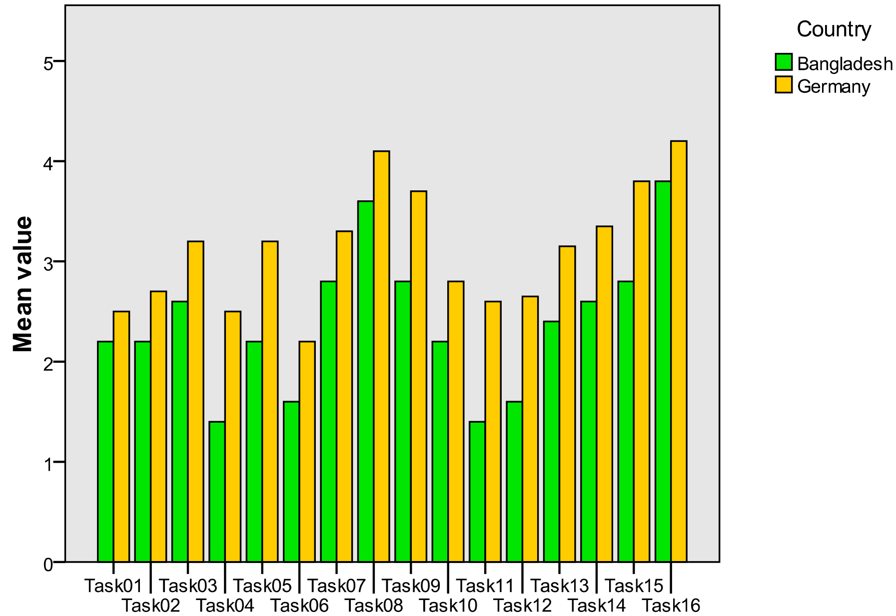


Figure 5.4.: The degree of complexity of the tasks assessed by experts / teachers.

5.4. Conducting the Test and the Test Process

The test was conducted as planned. Sitting arrangements were made allowing enough space between students so that one can not see the answers of others. A class teacher and the author himself were present while the test was running (test monitoring).

Before beginning the test, students received a briefing, for example, why they are going to take the test, in order to motivate the students. Also, the guidelines for taking the test were read out to the students as given on the first page of the questionnaire (Appendix A).

Students were allowed to use calculators for the mathematical calculations. But no handbook or text book was allowed[2]. The duration of the test was found optimal.

5.4.1. In Bangladesh

In the second half of 2009, the author planned to conduct the test by local teachers without being there. However, due to many reasons it was not possible. Then, later, in February 2010 the author flew there from Germany and the test was conducted with a total of 160 polytechnic students. Among the five polytechnic institutes involved in this test, three were government run and two private / NGO run polytechnics. The government run polytechnics are (1) Dhaka

[2]In Bangladesh polytechnic students are not used to using handbook in the examination hall

Polytechnic Institute (DPI)) (2) Dhaka Mohila Polytechnic Institute (DMPI) and (3) Comilla Polytechnic Institute (CPU). DPI is the largest Polytechnic Institute in Bangladesh, established in early 1955. DMPI is the largest and the oldest poytechnic institute among four women polytechnic institutes in Bangladesh. Private sector polytechnics included are (1) Ahsan Ullah University - Institute for Technical and Vocational Education and Training (ITVET) in Dhaka and (2) the SAIC Institute of Management & Technology in Bogra.

Out of a total of 160 participants, 53 are women. They are students of DMPI. The number participants from private polytechnics is 50.

5.4.2. In Germany

The test was conducted within a period from July to October 2009. A total of 160, including 3 women, trainees from seven vocational schools in Baden-Württemberg participated in this test. On request of some of the school administrations, the names of the participating schools are not given here. However, the author received all kinds of support from the administrations and from the teachers that allowed him to conduct the test successfully.

5.5. Reliability and Test Items Analysis

Each measurement (response to an item) reflects to some extent the true score for the intended concept, and to some extent unusual, random error. A measurement is reliable if it reflects mostly true score, relative to the error. Below there are some methods of estimating the reliability.

5.5.1. Internal-Consistency Reliability

To proof the reliability of the test items the *internal consistency* has been computed using the formula $\alpha = (k/(k-1)) * [1 - \sum(s_i^2)/s_{sum}^2]$. This is the most common index of reliability, namely, Cronbach's coefficient *alpha* (α). In this formula, the s_i^2 denote the variances for the k individual items; s_{sum}^2 denotes the variance for the sum of all items. If there is no true score but only error in the items, then the variance of the sum will be the same as the sum of variances of the individual items. Therefore, coefficient alpha will be equal to zero. If all items are perfectly reliable and measure the same thing (true score), then coefficient alpha is equal to 1.

5.5.2. Split-Half Reliability

Alternatively, the reliability has been checked using the Spearman-Brown *split-half reliability* formula, $r_{sb} = 2r_{xy} / (1 + r_{xy})$, in which the sum scale (total scores) is divided in some random manner into two halves. In the above formula, r_{sb} is the split-half reliability coefficient, and r_{xy} represents the correlation between the two halves of the scale (Lienert & Raatz, 1994). If the sum scale is perfectly reliable, we would expect that the two halves are perfectly correlated (i.e., $r = 1.0$). Less than perfect reliability will lead to less than perfect correlations.

5.5.3. Designing a Reliable Scale

In order to design a reliable scale the following methods were followed:

Step 1. generating items - more items in a questionnaire cancel random errors each other and make a sum scale more valid and to gain as wide a perspective on the concept as possible. However, in practice, the number of items on a questionnaire is usually limited by various other factors (e.g., respondents get tired, organisational reasons, etc.).

Step 2. choosing items of optimum difficulty (item-selectivity) - In the first draft of the questionnaire as many items as possible were included. This questionnaire was then administered to an initial sample of students, and examined the results for each item. First, various characteristics of the items were looked at, for example, in order to identify *floor* or *ceiling* effects. If all students answer to an item (in)correctly, then it does not contribute to discriminating between students, and thus, it is useless for the design of a reliable scale. In essence, those items are eliminated by looking at the item means and standard deviations that show extreme means, and zero or nearly zero variances.

Step 3. choosing internally consistent items - in which the correlation between the respective item and the total sum score (without the respective item), the squared multiple correlation between the respective item and all others, and the internal consistency of the scale (coefficient alpha) if the respective item would be deleted were calculated. Thus a reliable scale was made up of items that yield higher Chronbach's α and by deleting items that contribute less or negatively to Cronbach's α.

Step 4: Item Modification and/or Returning to Step 1. To make up the overall scale reliable some items in the questionnaire were modified, for example, better explained to enhance the comprehensibility, etc.

5.5.4. Results of the Reliability Test

The Cronbach coefficient (α) and the Spearman-Brown coefficient were found 0.858 and 0.890, respectively. The calculations were made considering all 16 tasks in a group.

Considering the test items in three separate categories: the category *Remember*, *Understand* and *Apply*, the reliability coefficients were as shown in Table 5.2.

Table 5.2.: The Results of the Reliability Test

Types of Test	Total	*Remember*	*Understand*	*Apply*
Cronbach coefficient	0.858	0.603	0.677	0.725
Spearman-Brown coefficient	0.890	0.596	0.783	0.659

6. Empirical Proof of the Hypotheses

6.1. Overview of the Statistical Tests used for Test Scores Analysis

In this section, the statistical procedures are presented that were used to analyze the data / scores obtained by students / trainees in the competency test conducted in Bangladesh and Germany. These brief descriptions are followed by exemplary application(s) in each case in order to concretise the use of the procedure.

T-Test

The t-test (Student, 1908) is a statistical data analysis procedure mostly used for testing if the difference between the mean values of 2 groups is statistically significant and is unlikely to have occurred by chance. The t-test assumes various conditions (normal distribution, variance homogeneity, symmetry) of the characteristic distribution of the dependent variable. Should one or more of the conditions be violated, requires the use of alternative test procedures (Diehl & Staufenbiel, 2001, p. 214). Equal sample size is also a condition of not being affected the precision of the t-test, if the variance is not equal (Bortz, 2005, p. 141). There are several kinds of t-tests, but here the "two-sample t-test" also known as the "Student's t-test" or the "independent samples t-test" will be used to compare the data (mean values) between two countries. That is, the two-sample t-test simply tests whether or not two independent populations have different mean values on some measure. Therefore, this test will be used in order to verify if the polytechnic students in Bangladesh differ more than just coincidence from the trainees in Germany in terms of acquired professional competence.

For example, in this research project the technical competency of Bangladeshi students undergoing 4-*Year Diploma-in-Engineering* may be different than that of German students undergoing $3\frac{1}{2}$-year apprenticeship training under the dual-system vocational education programme. To measure the competencies of students (random samples) of both countries, a common test was used. The *null hypothesis*, which is assumed to be true until proven wrong, is that there is really no difference between these two groups. These two groups of students may have different average scores. But there may be a real difference between the two groups, or just a chance difference in these samples. The t-test statistic determines a p-value (probability value) that indicates how likely these results could have been gotten by chance. By convention, if the p-value is less than 0.05 ($p < 0.05$), it is concluded that the null hypothesis can be rejected (i.e., the two groups are different). In other words, when $p < 0.05$ we say that the results are statistically significant [(Bortz, 2005); (Diehl & Staufenbiel, 2001)].

Test for homogeneity of variances using Levene test

The applicability, i.e. the robustness of the t-test is linked to the above mentioned conditions. The test for compliance of variance homogeneity of distributions are made by Levene test. This test is integrated in the t-test. If the test fails significantly, the robust Welch-test is applied (Diehl & Staufenbiel, 2001, p. 214f.)].

Analysis of Variance (ANOVA)

In statistics, analysis of variance (ANOVA) is a collection of statistical models, and their associated procedures, in which the observed variance is partitioned into components due to different explanatory variables. In its simplest form ANOVA provides a statistical test of whether or not the means of several groups are all equal, and therefore generalizes Student's two-sample t-test to more than two groups. ANOVAs are useful in comparing three or more means.

In practice, there are several types of ANOVA depending on the number of treatments and the way they are applied to the subjects in the experiment:

- *One-way ANOVA* is used to test for differences among two or more independent groups. Typically, however, the one-way ANOVA is used to test for differences among at least three groups, since the two-group case can be covered by a t-test (Gosset, 1908). When there are only two means to compare, the t-test and the F-test are equivalent; the relation between ANOVA and t is given by $F = t^2$.
- *Factorial ANOVA* is used when the experimenter wants to study the effects of two or more treatment variables.
- *Repeated measures ANOVA* is used when the same subjects are used for each treatment. This will be used to compare students/trainees' performance in three different cognitive process categories.

- **Mixed-design ANOVA**. When one wishes to test two or more independent groups subjecting the subjects to repeated measures, one may perform a factorial mixed-design

ANOVA, in which one factor is a between-subjects variable and the other is within-subjects variable. This is a type of mixed-effect model.

- *Multivariate analysis of variance (MANOVA)* is used when there is more than one dependent variable.

There are various models of analysis of variance. A general linear model (with varieties of test processes) will be used for analysis of data in this work. It makes the following assumptionss: independence of cases - that two events are independent intuitively means that the occurrence of one event makes it neither more nor less probable that the other occurs; normality the distributions of the residuals are normal; Equality (or "homogeneity") of variances, called homoscedasticity the variance of data in groups should be the same.

In order to apply the appropriate test process the homogeneity of the variances must be checked. Levene's test for homogeneity of variances is typically used to examine the plausibility of homoscedasticity. The KolmogorovSmirnov or the ShapiroWilk test may be used to examine normality. It the assumption of the homogeneity of variances fails, a more robust test, the Brown-Forsythe test, that is very similar to the Levene test is applied. Specifically, the absolute deviation (from the group means) scores can be expected to be highly skewed; thus, the normality assumption for the ANOVA of those absolute deviation scores is usually violated. This poses a particular problem when there is unequal n in the two (or more) groups that are to be compared (this is not the case in this work, where n = 160 and equal for both groups).
ANOVA will be used to compare the students performance in three different categories: *Remember*, *Understand* and *Apply*.

Mauchly's sphericity test

Mauchly's sphericity test is a statistical test used to validate repeated measures factor of analysis of variances (ANOVAs). Sphericity relates to the equality of the variances of the differences between levels of the repeated measures factor. Sphericity requires that the variances for each set of difference scores are equal. Sphericity is an assumption of an ANOVA with a repeated measures factor (RMF). When the significance level of the Mauchlys test is < 0.05 then sphericity cannot be assumed (Mauchly, 1940).

Departures from the assumption of sphericity affect the validity of various statistical tests used in the analysis of variance. Corrections for violations of sphericity include the *Greenhouse-Geisser*, the *Huynh-Feldt* and the *Lower-bound* corrections. To correct for sphericity, these corrections alter the degrees of freedom, thereby altering the significance value of the F-ratio. There are different opinions about the best correction to apply. A good rule of thumb is to use the

Greenhouse-Geisser estimate unless it leads to a different conclusion from the other two.

The Effect Size

Cohen's d: Cohen's d is an effect size (a measure of the strength of the relationship between two variables in a statistical population, or a sample-based estimate of that quantity) used to indicate the standardised difference between two means (Cohen, 1988). It can be used, for example, to accompany reporting of t-test. Cohen's d is an appropriate effect size for the comparison between two means. Cohen's d can be readily calculated as the difference between the means divided by the pooled SD. The generally accepted regression benchmark for effect size comes from (Cohen, 1992; 1988): 0.20 is a minimal solution (but significant in social science research); 0.50 is a medium effect; anything equal to or greater than 0.80 is a large effect size [(Keppel & Wickens, 2004); (Cohen, 1988); (Bortz, 2005)].

Eta-squared: The Eta-squared (η^2) is a measure of effect size for use in analysis of variance (ANOVA). It is equivalent to non-linear correlation coefficient, proportion of variance in Y explained by X or proportion of variance in X explained by Y. It ranges between 0 and 1. It is calculated as $BetweenGroupsSumofSquares / TotalSumofSquares$. Interpret as for r^2 or R^2; a rule of thumb: 0.01 (small effect), 0.06 (medium effect) and 0.14 (large effect). η^2 is not provided by SPSS, but it calculates partial eta-squared (η_p^2).

Partial η^2 (Partial Eta-squared): The partial Eta-squared describes the "proportion of total variation attributable to the factor, partialling out (excluding) other factors from the total non-error variation" (Pierce et al., 2004, p. 918). Partial Eta squared is normally higher than eta squared (except in simple one-factor models).

6.2. Proof of Hypotheses

To prove or disprove the hypotheses in this study mainly the quantitative method and in some cases the qualitative analysis were used. Particularly for Hypothesis the qualitative method was preferred. For quantitative analysis the data of a competency test and of teachers' assessment of the test items were used. The competency test consisted of 16 tasks. The measurement was made on a total of 100 points. The test design, test item construction, its validity, et cetera, have been discussed in Chapter 5. This test was conducted in Bangladesh and in Germany (details about these two participating groups can also be seen in Chaper 5, Section 5.1.1 and 5.1.2, respectively.

6.2.1. The Competency Level of Polytechnic Graduates in Bangladesh

Hypothesis H1 states:
The competency level, in the case of application-oriented tasks, achieved by the polytechnic students/graduates in Bangladesh at the end of the Four-Year Diploma-in-Engineering course is lower than that of the vocational school (Berufsschule) trainees in Germany at the end of the Three-and-One-Half-Year Apprenticeship Training in the Dual System.

In order to examine this hypothesis the competency, mainly the technical competency, was measured through a competency test. As mentioned earlier in Section 5.2, the test included mainly practical relevant tasks. A total of 160 polytechnic students in Bangladesh and a total of 160 trainees of vocational schools in Germany participated the test within the late 2009 and the beginning of 2010.

The average points achieved by students/ trainees of both countries were found far below 50%. The students of polytechnic institutes in Bangladesh obtained only 9.27 points out of a total 100. and the trainees of vocational schools in Germany 36.42 points, on average. That means, Bangladeshi polytechnic students lag far behind the German apprentice trainees by a point difference of 27.15. In other words, the polytechnic students in Bangladesh received only a fourth of what the German vocational school trainees obtained in the competency test.

Figure 6.1 and 6.2 show the histogram and Figure 6.3 shows the average values +/1 SD (standard deviation) of points obtained by polytechnic students and vocational school trainees.

In order to verify if the difference between the average values of the two groups determined above is statistically significant and is unlikely to have occurred by chance, the "*two-sample t-*

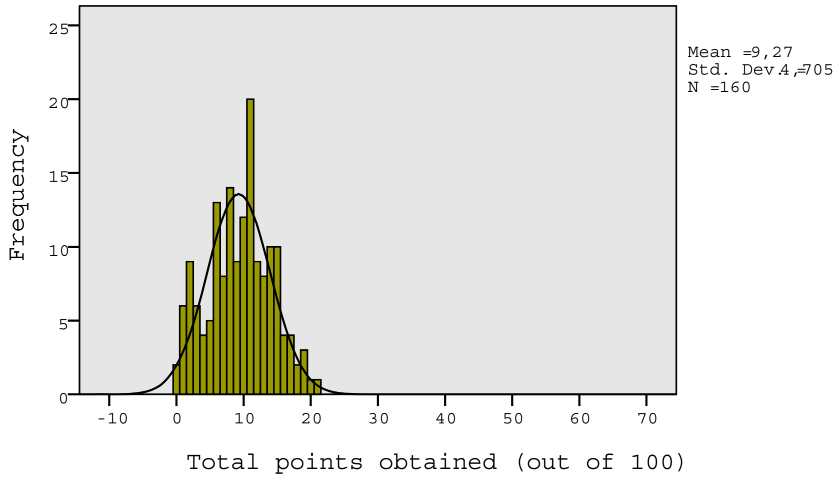


Figure 6.1.: Histogram of points obtained by polytechnic students in Bangladesh

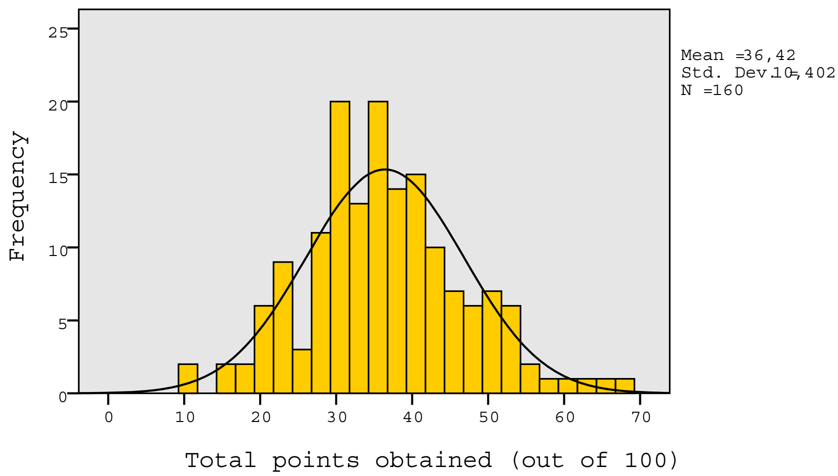


Figure 6.2.: Histogram of points obtained by polytechnic students in Germany

test" was carried out. The findings of this "*t-test*" are given in table 6.1. The various parameters of this test are: $t = -30.08$ (the negative sign indicates that Bangladeshi polytechnic students lag behind the German vocational school trainees), the degree of freedom, $df = 221.45$, the significance (two-tailed), $p < .001$, the partial eta-squared, $\eta_p^2 = 0.74$ and the Cohen's $d = 3.60$. In this case, the estimated p is very much less than the normally accepted significance level of 0.05 (significant) and / or 0.01 (very significant) [(Bortz, 2005); (Diehl & Staufenbiel, 2001)]. This proves that in no way are the average values of these two groups equal. In other words, the probability of these two average values being equal is strongly rejected. The effect size is estimated and expressed by the partial eta-squared, η_p^2, which is $0.74 >> 0.14$ (large effect) and the Cohen's d is 3.60 which is also high compared to 0.80 (large effect) (Bortz, 2005, p. 143).

Thus, *Hypothesis H1 is proved positve.*

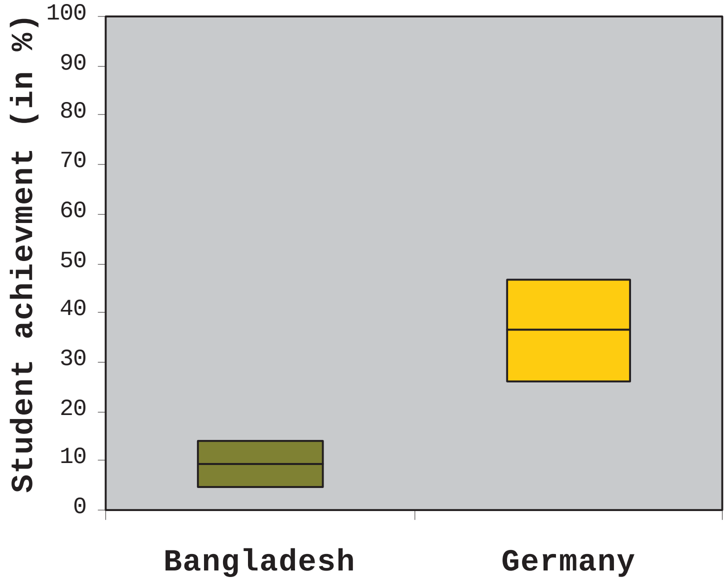


Figure 6.3.: Students' performances in competency test (average value +/- 1 SD) of polytechnic students in Bangladesh and vocational school trainees in Germany.

Table 6.1.: Comparison of student achievement (overall) in competency test: results of t-test and measures of effect size.

	Mean	SD	Min	Max	t	df	p	η_p^2	Cohen's d
Bangladesh	9.27	4.71	0.0	21.0	-30.08	221.45	< 0.001	0.74	3.60
Germany	36.42	10.40	10.5	68					

Unfortunately, these findings support the private sector employers' negative assessment about the skills of polytechnic graduates (Oxtoby, 1997). Experts and teachers working in TVET sectors in Bangladesh told the author in an interview that private sector employers' prefer graduates from non-government organisation (NGO)-run technical institutes. These technical institutes offer training courses at Certificate level. Some students of polytechnic institutes also told the author that immediately after completing the *Diploma-in-Engineering* course they go to some NGO-run technical institutes, situated in Dhaka, in order to achieve the practically oriented knowledge and skills demanded on the job market.

Discussion

1. For none of the 16 tasks (Task 1 to 16) Bangladeshi polytechnic students obtained higher or equal points compared to the trainees in Germany. However, their performance was comparable with the trainees in Germany in case of Task 1, 4 and 6. The following histograms in Figure 6.4 to 6.6 show how they performed in the test, particularly for these three tasks. Task 1 de-

mands the knowledge of digital logic gates, relays and contactors. It consists of two assessment items: Q1.1 (category *Remember* of *Factual* knowledge, 2 points) and Q1.2. (category *Understand* of *Factual* knowledge, 1 point). The points obtained by polytechnic students and vocational trainees were 1.5 and 1.6, on average. But what is different between the two countries in this particular case is the largest number (81, 50.6%) of polytechnic students obtained 2 and the largest number (48, 30%) of vocational trainees obtained 3 (Figure 6.4). Another difference is that only 22 (13.8%) polytechnic students could answer both questions, Q1.1 and Q1.2 correctly, whereas 48 (30%) trainees could answer these both questions.

Bangladeshi and German teachers estimated the probability of solutions for Task 1 to 3.8 and 4.5, respectively. Bangladeshi students and German trainees performed also proportionately. Now the question is “Why could students / trainees not perform as well as it was expected?” The most probable answer is as follows: generally, students / trainees are used to switching ‘ON’ a load (e.g. lamp, motor) by applying a ‘high’ potential, i.e. greater than 0, the other end of the circuit is grounded. Students who will answer this question by simply recalling or recognizing from their long time memory, will, certainly, make a mistake. Because, in this particular case, the relay is already supplied with ‘high’ potential (+5 V) (Section 5.2.3, Task 1 - Figure 1). It will operate only when the other end of the relay coil is put to a ‘low’ potential (0 V). That means this assessment item demands a good conceptual type of knowledge.

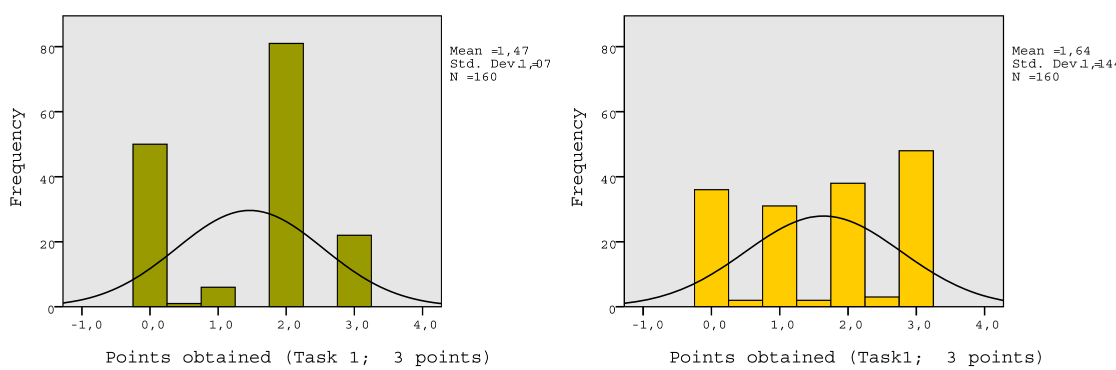


Figure 6.4.: Histogram of points obtained for Task 1 by polytechnic students in Bangladesh (left) and vocational school trainees in Germany (right)

Task 4 was of the category *Remember* of factual knowledge. It tested if students / trainees know common types of sensors and their areas of applications. Task 6 was also of the category *Remember* of factual knowledge. It was about an RS-flipflop. Figure 6.5 and 6.6 show the differences in these two tasks between the two groups of students / trainees.

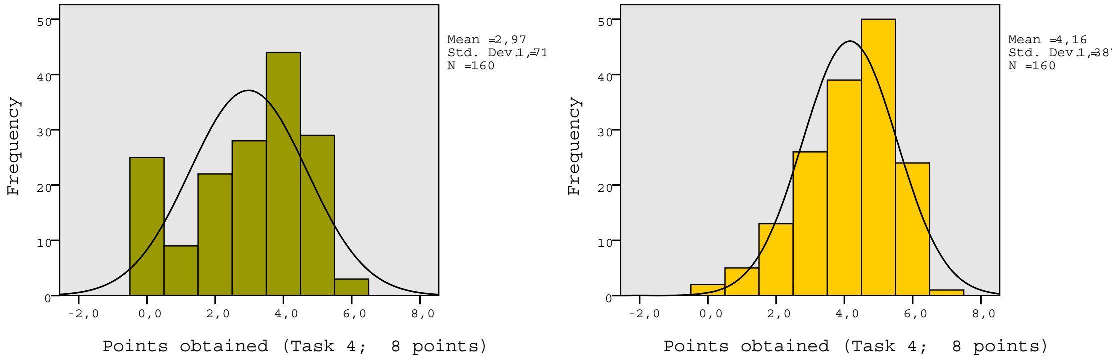


Figure 6.5.: Histogram of points obtained for Task 4 by polytechnic students in Bangladesh (left) and by vocational school trainees in Germany (right)

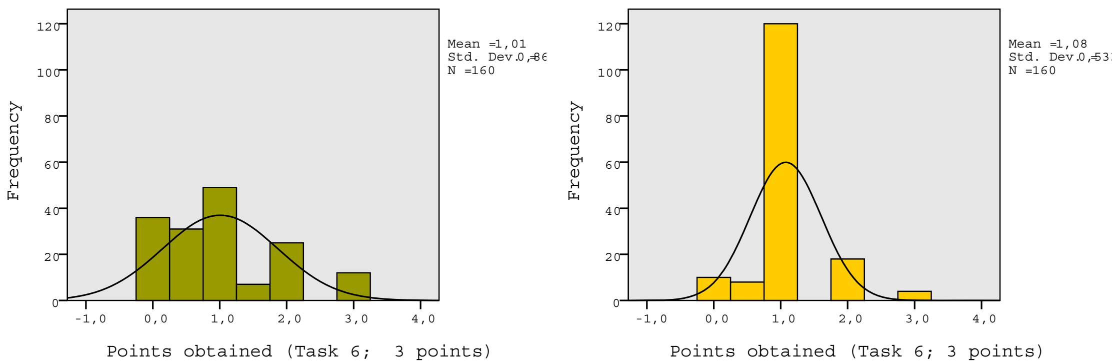


Figure 6.6.: Histogram of points obtained for Task 6 by polytechnic students in Bangladesh (left) and by vocational school trainees in Germany (right)

2. Task 10 was a "*programme segment*" using C programming language that implements a logic gate. Students were supposed to read this given programme code and name the correct logic gate. No polytechnic student could solve this task. The mean point was zero. This language is taught at Polytechnics in Bangladesh. But it is limited to learning the language semantics and syntaxes only. Implementation of soft-/firmware for practical relevant tasks using the *C* language are not practised in the electronics technology course in Bangladesh. Among the 160 trainees in Germany twenty obtained 2 points out of 3. It is to mention that C language is not taught at vocational schools in Germany, instead, assembly language is taught. This task was classified as the category *Understand* of conceptual knowledge.

3. Task 8 was concerned with an electronic device. A schematic circuit diagram was presented that uses mainly a relay and two transistors. Most of the assessment items regarding this task were classified in the category *Apply* of conceptual knowledge. Eighty out of 160 polytechnic students ignored Task 8. They were given zero points for this task. The points obtained by the rest of the students were between 1 and 4, out of 15 points. An analysis of the examination questions shows that polytechnic students are assessed for mainly theoretical and discrete

knowledge at the category of *Remember*.

On the other hand, one half (50%) of the vocational school trainees in Germany obtained 4 points or above for this task. About 2% of the trainees obtained more than 11 ponits (80%) out of max 15 points. The histograms in Figure 6.7 show how polytechnic students in Bangladesh and vocational school trainees in Germany performed in this particular task, Task 8.

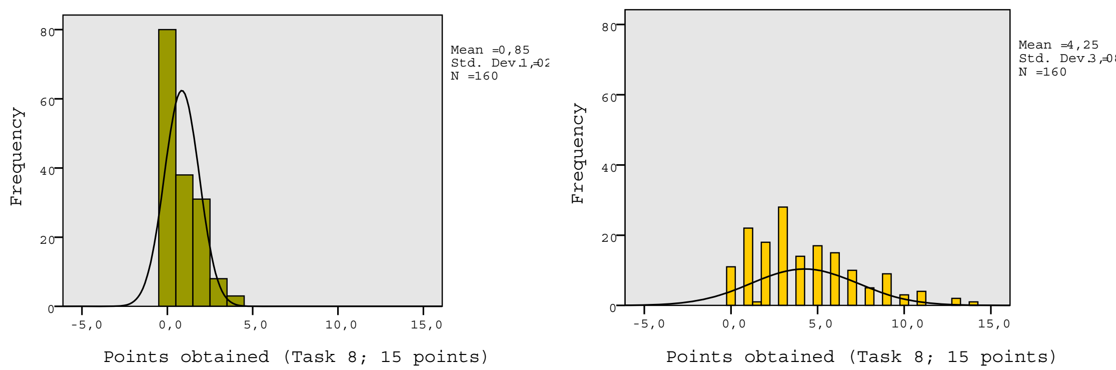


Figure 6.7.: Histogram of points obtained for Task 8 by polytechnic students in Bangladesh (left) and by vocational school trainees in Germany (right)

4. Task 14 was used to assess students'/ trainees' knowledge and understanding of the function of Emergency STOP switch. An example of the application of the Emergency STOP switch with PLC for human and machine safety was provided in this task. Students' performance in this particular task shows that about 88% of the participating candidates in Bangldesh have almost no knowledge of this particular area of machine safety. They obtained $\leq$ 0.5 out of 3.5. The rest showed only little performance.

This figure in Germany is totally different. About 70% of the trainees obtained points between 2 and 3.5, inclusively. Almost half of them (48.2%) obtained 3 or above out of maximum 3.5 points.

5. The last task (Task 16) was designed to assess students' knowledge and skills in PLC (SPS) technique at the level of *Apply*. Students were asked to write a control programme for a simple construction elevator using "Functional block or Ladder diagram" technique. No student in Bangladesh managed this task. All of them obtained zero points. Vocational school trainees, on the other hand, performed relatively far better than the polytechnic students in Bangladesh. They obtained an average of 5.2 points out of 14. About 38% obtained 7 or more points for this task.

Some more answers to the question of "*Why could Bangladeshi polytechnic students not perform well compared to Germany's vocational school trainees?*" can be found in the verification of Hypothesis H6 in Section 6.2.6.

The complete results of the competency test is given in Appendix B.2.

6.2.2. Student Performance at Different Cognitive Levels

Hypothesis H2: *The tasks, which require only knowledge reproduction, are solved correctly with a higher probability than the tasks, which require higher level cognitive processes.*

To examine the above stated hypothesis the assessment items were classified in three categories: *Remember* (level 1 - 'reproduction') through to *Understand*(level 2 - 're-organisation') and *Apply* (level 3 - 'transfer') plus *Analyze* (Table 5.1). There were 37 assessment items in the test. For each item points were allocated. The cognitive category *Remember* included 14 items bearing 32 points, the category *Understand* included 12 items bearing 22.5 and the category *Apply* (plus Analyze) included 11 items bearing 45.5 points. The allocated points in each category were normalized to a scale of 100. The points obtained by students/ trainees in a particular level of cognitive process is the measure of the students'/ trainees' performance on that level.

In the competency test students performed almost the same in the categories of *Remember* (mean value, MD = 27.1 and standard deviation, SD = 14.0) and *Understand* (MV = 28.1 and 22.2), but the performance in the category of *Apply* was the least (MV 17.3 and SD = 17.8). The Bar diagram in Figure 6.8 shows the average values of the points obtained by students/trainees in three categories.

It was found that the mean difference between the categories *Remember* and *Understand* is only 1.1% and it is not significant (p = 0.788). The category *Apply* differs significantly from *Remember* by -9.8%, $p < .001$ and from *Understand* by -10.8%, $p < .001$.

Thus, *Hypothesis H2 is confirmed* only in the case of comparison between the categories of *Remember* (reproduction) and *Apply* (transfer). But in the case of *Remember* (reproduction) and *Understand* (re-organisation) students and trainees showed similar performance.

The test results support the hypothesis only partially. That means: "*The tasks, which require only knowledge reproduction (for example, category Remember), are solved correctly with a higher probability than the tasks, which require the cognitive process level of Apply)*".

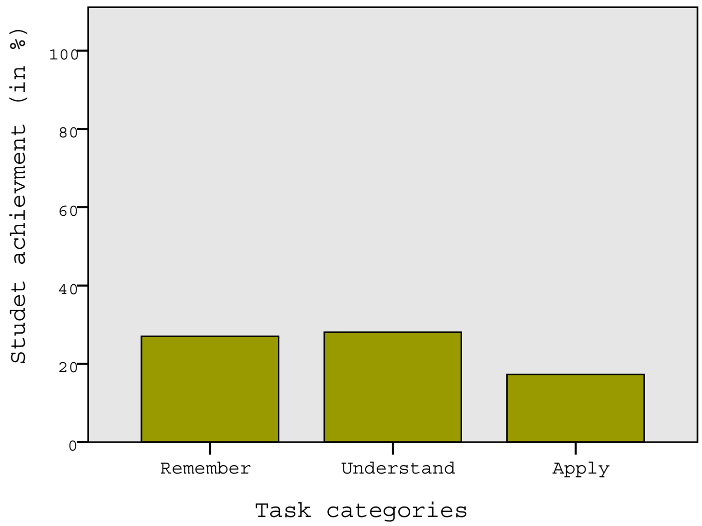


Figure 6.8.: Student performance in different cognitive process categories.

Discusion

Student / trainee performance in the categories of *Remember* and *Understand* were almost the same. These can be explained as follows:

1. German trainees are used to using Handbooks (Tabellenbuch) in the examination hall. Often they do not have to retrieve relevant knowledge (factual information) from long term memory, particularly during the examination or test. But, in this competency test handbooks were not allowed.

2. The situation in Bangladesh is different. Handbooks are not allowed here. A student is to remember / recall the knowledge (factual information) required to solve a task, unless it is supplied.

3. Item classification (according to Bloom / Anderson & Krathwohl Taxonomy of learning objectives) is often difficult (ambiguous). Because, *firstly*, a task often requires a combination of two or more knowledge categories which are often not separable. *Secondly*, the level of complexity of a task highly depends on an individual's prior knowledge and / or proficiency, i.e. if he / she has performed the same / similar task previously.

The students' / trainees' competence level at the category of *Apply* was found much lower than the competence level at other two categories – *Remember* and *Understand*. The solution of a task of the category of *Apply* usually requires knowldge that is to be produced by an individual, generally based on his / her prior knowledge (knowledge production). That means, most of the students / trainees were unable to transfer their knowledge to solve the tasks or they did not have required prior knowledge.

The following hypothesis (H3) is similar to this one. In the case of H3 there will be a comparison between the two countries, i.e. data (student performance) will be analyzed separately. It will provide more inside pictures and further evidence related to this hypothesis.

6.2.3. A Comparison of Student Performance: at Different Cognitive Levels in Bangladesh and Germany

Hypothesis H3: *In answering the tasks that demand mainly higher level cognitive processes, the performance level differs notably between the polytechnic students in Bangladesh and vocational school trainees in Germany.*

To (dis)prove Hypothesis H3 the 37 items of the 16 tasks used in the competency test were classified into three cognitive process categories according to the Anderson & Krathwohl (2001) Taxonomy. As mentioned in the foregoing sections the technical competency test included assessment items of different categories and with different levels of complexity within the field of electronics technology. Generally, the assessment items in the category *Apply* demand mainly higher level cognitive processes compared to the tasks in the categories *Understand* and *Remember*. As mentioned earlier the cognitive process category *Apply* is the highest level considered in this study. Any assessment items that require the cognitive process category *Analyze* were included in the category *Apply*.

Polytechnic students in Bangladesh and vocational school trainees in Germany took the competency test. Variance analysis (ANOVA) was used to examine the differences between the test results (student achievements) of polytechnic students and vocational school trainees. The analysis was carried out in the following two cases: case 1) the performance difference between the two countries in three cognitive process categories *Remember, Understand* and *Apply* (considering *Factual, Conceptual* and *Procedural* knowledge, together i.e. independent of the types of knowledge) and case 2: The performance difference between the two countries in the cognitive process category *Apply* (considering *Factual & Conceptual* knowledge and *Procedural* knowledge, separately)

Case 1: Student performance differences between Bangladesh and Germany in the cognitive process categories of *Remember*, *Understand* and *Apply* (irrespective of the types of knowledge)

The average values of the test results of polytechnic students in Bangladesh (N = 160) and vocational school trainees in Germany (N = 160) are presented in Figure 6.9. It can be seen from this bar graph how the performances of students/ trainees vary with different levels such as *Remember* (level 1), *Understand* (level 2) and *Apply* (level 3).

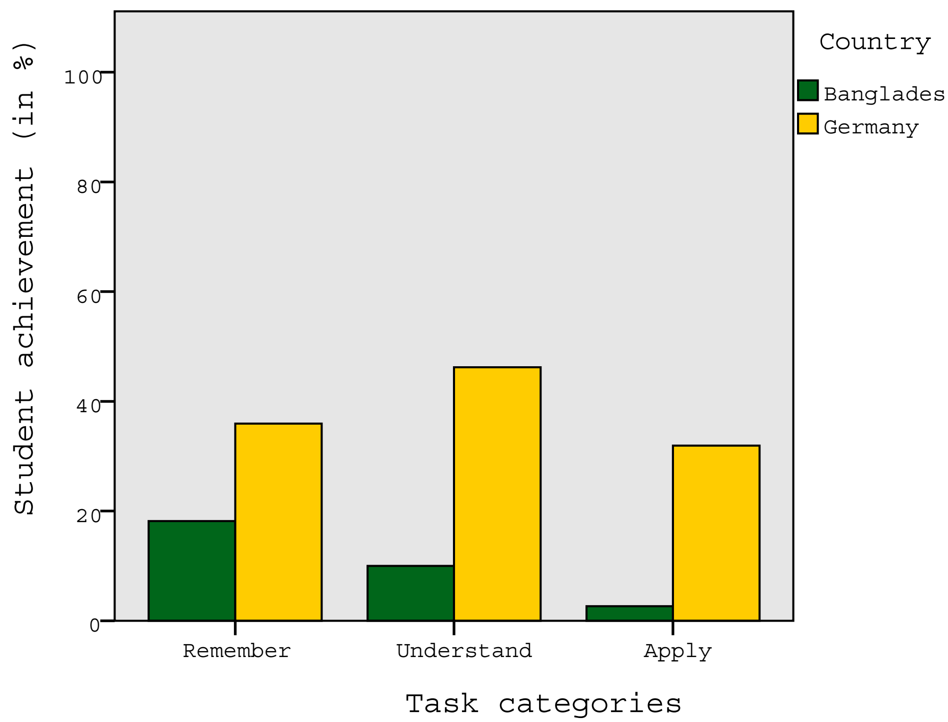


Figure 6.9.: Student performance in different cognitive process levels.

Table 6.2.: Comparison of student achievement on different levels of the cognitve process. BD = Bangladesh, DE = Germany

Cognitive Process Levels	Points (in %)		SD		Med		Mod		Min / Max	
	BD	DE	BD	DE	BD	DE	BD	DE	BD	DE
Apply	2.6	31.9	2.9	13.9	2.2	31.9	0	17.6	0 / 11.0	2.2 / 76.9
Understand	10.0	46.2	8.2	16.2	8.9	46.7	4.4	55.6	0 / 37.8	4.4 / 86.7
Remember	18.18	35.9	10.1	11.4	18.8	34.4	21.9	43.8	0 / 51.6	12.5 / 71.9

The statistics and the effects within these three categories (levels) and between the two countries are given in Tables 6.2 and 6.3, respectively.

Table 6.3.: Effects of within "Task Categories" and between countries

Sources of variation	N	F	df	p	η_p^2
Country	160	891.83	1, 318	$< .001$	0.74
Task category	160	130.76	2, 636	$< .001$	0.29
Task category*Country	160	79.86	2, 636	$< .001$	0.20

The above findings show that the Bangladeshi polytechnic students lag far behind the German vocational school trainees not only on the cognitive process level *Apply* (level 3) but also on the levels of *Understand* and *Remember*. However, the differences between the two countries in the categories of *Apply* and *Understand* are bigger than the difference in the category of *Remember*. For example, in the category of *Apply* Bangladeshi polytechnic students were far behind the German vocational school trainees by a mean difference of -29.3% (average points 2.6% (Bangladesh) - 31.90% (Germany)), in the category of *Understand* it was -36.2% (10.0% (Bangladesh) -46.2% (Germany)) and in the category *Remember* -17.7% (18.2% - 35.9%). The variance analysis (ANOVA) confirms these findings with significance, $p < .001$% (Table 6.3).

Case 2: Student performance difference between the two countries in the cognitive process category *Apply* (considering *Factual & Conceptual* knowledge and *Procedural* knowledge, separately)

In this case it was examined how student performance varies between the two countries in the category of *Apply* of *Factual & Conceptual* knowledge and of *Procedural* knowledge. All tasks in the category *Apply* were grouped into two: Task-Group-Apply (Factual & Conceptual) and Task-Group-Apply (Procedural). The complete list of items in these two groups and also in other categories can be seen in Table 5.1 of Chapter 5.

For example, Task 16 was classified in the category of *Apply* of *Conceptual knowledge*. *Conceptual knowledge* includes schemas, mental models, etc. (Anderson & Krathwohl, 2001, p. 48). These schemas and mental models represent the knowledge an individual has about how a particular subject matter is organised and structured, how the different parts or bits of information are interconnected and interrelated in a more systematic manner and how these parts function together (ibid). Procedural knowledge is the "knowledge of how" to do something. It includes knowledge of skills, algorithms, techniques and methods (Anderson & Krathwohl, 2001, p. 52). The Task 16 was described as below:

Small Controllers / PLC
Task 16: You have got a contract to develop a control programme for a construction lift (Figure 13). As a controlling device you will be using a small controller (or a PLC). The lift basket should be able to move between the two limit switches S2 at the top and S4 at the bottom automatically. When the 'Stop' button is pressed, the lift should stop immediately. If the 'Up' / 'Down' button is pressed, the drive should continue its journey automatically. A three-phase motor (M) is used as drive. The motor is switched on/off via contactors Q1 (Up) and Q2 (Down). A protective interlocking and a locking latch in the programme of the controller must be used to prevent the motor from simultaneous right-left run. When the motor is overloaded the lift must be stopped by the over current relay (F1) immediately.
Q16 Draw the functional block diagram (FBD) or ladder diagram (LD) for this control programme.

To solve this assessment item (Item Q16) students mainly require a comprehensive conception of the total problem. Knowledge of how to draw functional block diagram (FBD) or ladder diagram (LD) (*Procedural knowledge* – method, technique, algorithm, etc.) is also required, but the *Conceptual knowledge* is the domonating type of knowledge in this particular case. Since this task mainly require the *Conceptual knowledge* it is classified in this knowledge category. Because this task is to be implemented newly using students' knowledge and skills in motors and logics, therefore it is classified in the category of *Apply*. Section 5.2.3 describes all the tasks, including Task16. A complete list of tasks is given in Appendix A.

Task 13, for example, is classified in the *Procedural knowledge* type and in the cognitive process category of *Apply*. This task is reproduced below:

Electrical Motors/Drives

Task 13
To drive a mobile robot DC motors with built-in gears are used. The motor data are N = 100 rpm at a voltage of V =+12 V.

Q13.1 The motors are operated from a battery voltage of Vb = +9 V.
Calculate the speed of the motors when operating with the battery.

Q13.2 The speed of the motors is controlled using a pulse width modulated (PWM) signal. The motors are supplied by a voltage shown in figure 10. The frequency of the signal is f = 100 Hz. The motors should run with a speed of N = 10 rpm. Determine the pulse duration t_i of V_{PWM}.

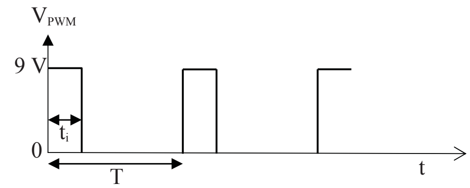


Figure 10: Periodic pulse with modulated control voltage

To solve this task a student should know "how to" calculate the speed of an electrical drive/ motor for a given supply voltage. That means, this task require mainy the procedural knowledge.

The test results are presented in Figure 6.10. This test also proves that the performance difference between the two counties is significant.

Table 6.4.: Comparison of student achievement (in %) between Bangladesh (BD) and Germany (DE) in the categories of Apply (Factual & Conceptual) and of Apply (Procedural)

Cognitive Process Levels	Mean		SD		Med		Mod		Min / Max	
	BD	DE	BD	DE	BD	DE	BD	DE	BD	DE
Apply(Factual &Conceptual)	2.3	30.8	3.2	15.2	0.0	29.0	0.0	38.7	0 / 16.1	0 / 80.7
Apply (Procedural)	3.2	35.5	4.6	17.1	0.0	35.6	0.0	35.6	0 / 17.8	0 / 91.1

Table 6.5.: Effects: between task categories: Apply (Factual & Conceptual) and Apply (Procedural), and between countries (Bangladesh and Germany)

Sources of variation	N	F	df	p	η_p^2
Country	160	705.40	1, 318	$< .001$	0.707
Task category	160	22.52	1, 318	$< .001$	0.045
Task category*Country	160	11.00	1, 318	0.12	0.020

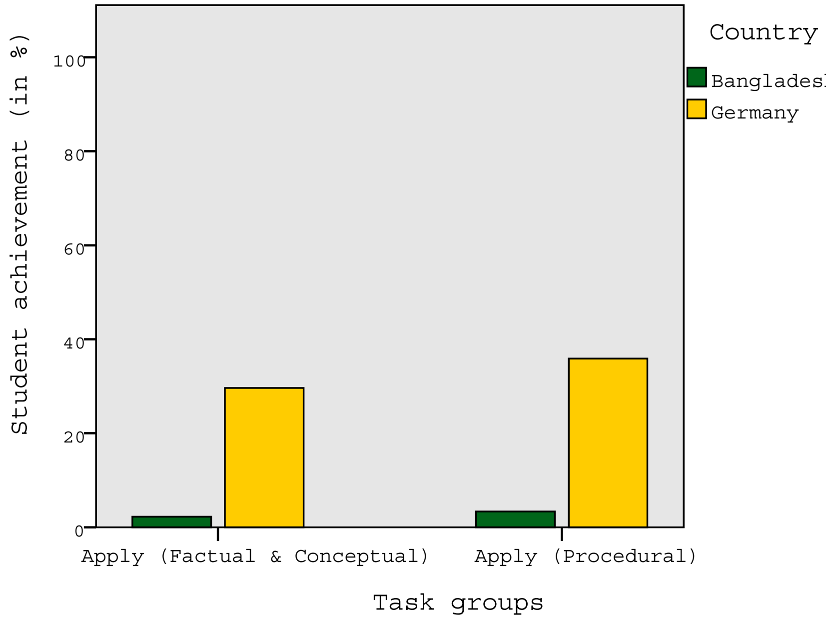


Figure 6.10.: Student performance (in %) in knowledge categories: 1. Factual & Conceptual (level *Apply*) and 2. Procedural (level *Apply*).

The findings in both cases show a substantial difference between the students in Bangladesh and trainees in Germany in answering the tasks that demand mainly higher level cognitive processes, i.e. the tasks in the category of *Apply*.

Thus, *Hypothesis H3 could be proved.*

Discusion

The curriculum content analysis and the analysis of student assessment procedure have shown that the Diploma curriculum mainly focuses on theoretical matters. The findings of examination questions analysis clearly indicate that only a little emphasis is placed on transfer-based tasks in Bangladesh compared to Germany. Trainees in Germany undergo an enterprise training that is much longer (apprx. three-fourth of the total training period, ref. Figure 4.8, p. 86) than the enterprise training undergone by the polytechnic students in Bangladesh (13.3%, ref. Figure 4.1, p. 75). Moreover, the learning field based curriculum in vocational schools in Germany focuses mainly on practice-oriented learning and teaching and foster trainees' knowledge transfer capability.

6.2.4. Teachers' Capability of Estimating their Students' Performance

Hypothesis H4: *The teachers are in a position to estimate the ability of the students to solve the tasks they are set.*

As mentioned above, a test (consisting of 16 tasks) was developed for student's competency measurement. This test was placed before the respective teacher(s), prior to conducting the test with their students. For each task set for the test the teachers were asked if they could estimate the probability that their students would be able to solve the tasks correctly. For each task the teachers specified a probability on a five-point scale, the lowest value was 1 (very low) and the highest value was 5 (very high). This estimated probability measures how well or bad students might perform in the proposed test. Then their students took the test. For each correctly solved task students received points. A student/ trainee could obtain a maximum of 100 points, if he or she could solve all the tasks correctly.

Figure 6.11 presents the average values of the probabilities estimated by teachers. For almost all

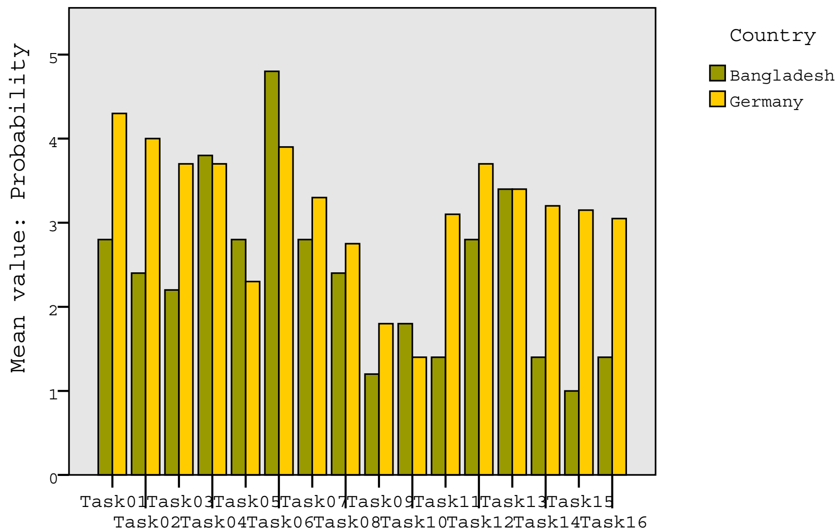


Figure 6.11.: Teachers' assessments (the estimated probabilities) of the ability of the students to solve the tasks they were set.

of the sixteen tasks, with some exception, Bangladeshi polytechnic teachers estimated a lower probability than the vocational school teachers in Germany. For example, the estimated probabilities for Task 4 and Task 6 were almost similar in the case of Bangladesh and Germany. Most probably the fact that their students would not do well, was the reason why Bangladeshi teachers did not show much interest in conducting the competency test. Initially they agreed, but, after seeing the test tasks and calculating that their students would not perform well, they refused to conduct the test.[1] The overall results, presented in Figure 6.1 and 6.2 in Section 6.2.1, confirm the teachers' ratings. Bangladeshi students performed at a much lower level than German apprentice trainees on average.

[1]When the author contacted the Bangladeshi polytechnic teachers for conducting the test, a couple of institutes refused, arguing that students did not learn in this way. Later, however, the author conducted the test there himself.

Bangladeshi teachers assigned c. 4.8 to Task 6. This was the highest solution probability among the 16 tasks estimated by teachers in Bangladesh. Bangladeshi students achieved 1.01 out of 3 points (33.3%, variance 0.863). That means there exists a direct correlation but teachers over estimated their students. The German teachers assigned c. 3.9 to Task 6 and the trainees obtained an average value of 1.08 (36.0%, Std. Dev = 0.533). This data shows also a direct correlation between teachers' estiamte and students's achievement. But it was also (slightly) overestimated. Teachers of both countries estimated a probability of c. 3.8 for Task 4. This was the next highest probability among the 16 tasks. Students in both countries also performed well in Task 4. Bangladeshi students obtained 2.97 out of 8 points (37.1%, Std. Dev = 1.72) and German trainees obtained 4.16 (52%, Std. Dev = 1.39) These results in this particular task are higher than the overall results (the overall average value of points was 9.27% for Bangladesh and 36.42% for Germany). It must be mentioned here that both Task 4 and Task 6 were classified under the cognitive process category *Remember* of *Factual & Conceptual* knowledge. The detailed description of these tasks has been given in Section 5.2.3.

Bangladeshi teachers assigned c. 1.0 (the lowest probability) to Task 9 and Task 15. In the test their students achieved about zero (0%) for both Task 9 and Task 15. On the otherhand, the teachers in Germany assigned a probability value 1.8 for Task 9 and 3.2 for Task 15 and their students achieved 1.37 out of 6.5 (21.2%, Std. Dev = 1.56) and 2.15 (42.9%, Std. Dev = 1.76), respectively.[2] Bangladeshi teachers estimated the probability for Task 1 with 2.8 (nearly a middle value between 'very high' and 'very low') and their students achieved 49.1% (a perfect match). Thus, in many individual cases, as explained above, teachers of both countries were able to estimate their students well.

To find out the (statistical) relationship between the teachers assessment and the students achievement in the competency test, a correlation test was used. The findings (the correlation test results) are presented in Figure 6.12 for Bangladesh and in Figure 6.13 for Germany. In both cases a correlation exists between the teachers assessment and the students achievement.

The correlation coefficients were calculated using the Spearman's model. This analysis shows that there exists a strong correlation, Bangladesh 0.790 with significance $\rho < .001$ and Germany 0.717 with significance $\rho = 0.002$, between teachers' assessment and students' achievement (Table 6.6).

Based on these findings explained above

[2] Note: Both Task 9 and Task 15 were classified as cognitive process category *Apply*.

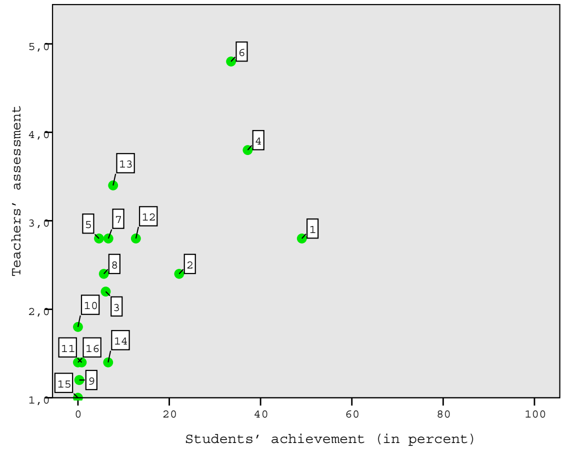


Figure 6.12.: Bangladeshi teachers' assessment (the probability that students can solve the tasks) and students' achievement

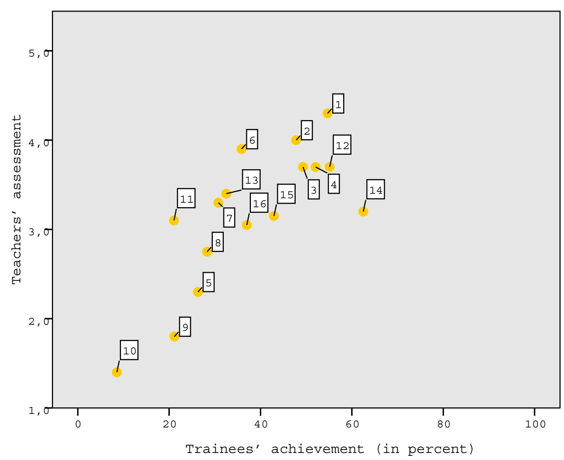


Figure 6.13.: German teachers' assessment (the probability that students can solve the tasks) and students' achievement

Hypothesis H4 can be confirmed.

Discussion

In general, teachers estimations were higher than their students' actual achievement. For example, Task 6, 13, 5, 7, 12, and 8 (Figure 6.12) in Bangladesh. Similarly, German Teacher assessed Task 11 with 3.1 points, but their students achieved only 21% (see figure 6.13), that is over estimation. Therefore, it can be said,

"In most cases, the teachers are able to estimate the difficulty of the tasks in relation to the others, but they overestimate students' achievement."

Table 6.6.: The correlations between teachers' assessment (the probability that students can solve the tasks) and students' achievement.

Country	correlation coefficient, *r* (Spearman's rho)	Sig. *p*	N
Bangladesh	0.790	$< .001$	16
Germany	0.717	.002	16

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

6.2.5. Comparison of Inter School/ Class Performance

Hypothesis H5 states:

The student performance between schools/ classes differs significantly.

A survey of student performance was conduced. The survey included six (6) classes of five (5) polytechnic institutes in Bangladesh and eleven (11) classes of seven (7) vocational schools in Germany. A detailed description of the survey is documented in Chapter 5. In this test students/ trainees were given a set of tasks that consists of thirty-seven (37) test items from different categories of cognitive process.

As described in Section 3.2.5, the context of polytechnic institutes in Bangladesh and that of vocational schools in Germany are not the same. Therefore, the test for the hypothesis was carried out taking into account the test data of the two countries separately. That is, the data of the two countries, Bangladesh and Germany, was analyzed independently. However, to investigate whether or not there are any differences in the performance among schools/ classes the univariate variance analysis (ANOVA) was used. ANOVA can detect group differences (two or more groups) on a given dependent variable. The dependent variable for this analysis were the points obtained by students out of total 100 points.

Comparison of Inter School/ Class Performance: Bangladesh

As described above, there were six (6) classes from five (5) polytechnic institutes in Bangladesh. Except Dhaka Mohila Polytechnic Institute (DMPI), each polytechnic had only one group/class who participated in the test. From DMPI two classes participated in the test. The profile of the different class-averages of student performance in Bangladesh are presented in Figure 6.14. The results of the ANOVA test, the degree of freedom (df) between classes, the F value, the significance of the F (Sig. p) and the partial eta squared (η_p^2), etc. are given in Table 6.7.

The six classes in Bangladesh differ between them with F value = 15.43 and the observed sig-

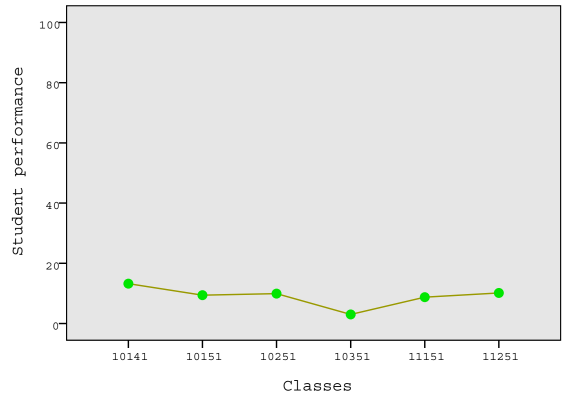


Figure 6.14.: Profiles of the class-averages of student performance in Bangladesh.

nificance level p is $< .001$.[3]

Table 6.7.: The student performance differences between classes in Bangladesh.

df	F	Sig. p	η_p^2
5, 154	15.43	$< .001$	0.334^a

a. R Squared = 0.334 (Adjusted R Squared = 0.312).

Thus, these results prove Hypothesis H5, particularly in the case of Bangladesh. That means, *the student performances between polytechnic institutes in Bangladesh differ significantly*.

The *Student Newman-Keuls* test, also labeled as 'post-hoc' analysis, was applied in order to make a posteriori pairwise comparison. This test reveals the differences between classes. The results of this test are given in Table 6.8.

In Table 6.8 Class 10351 within Subset 1 attained a class average of only 3.0 points (the lowest class average), whereas, Class 10141 under Subset 3 received an average point of 13.22 (the highest class average in Bangladesh). Other classes which belong to Subset 2 do not differ among themselves so much (p-value 0.604). But these classes differ between classes in Subset 1 and 3 significantly.

Discussion

Therefore, it can be generally formulated that *the student performances between polytechnic institutes in Bangladesh differ significantly (Hypothesis H5)*. But not all polytechnics differ from each other. There are polytechnics / classes whose performances are more or less similar ('post-hoc'

[3] If the class averages are all equal the F value is close to 1.0 most of the time. A large F ratio means that the variation among class-averages is more than it would be by chance.

Table 6.8.: Homogeneous subsets of different classes in Bangladesh

Student-Newman-Keuls [a,,b,,c]

Class	N	Subset of classes 1	2	3
10351	19	3,000		
11151	38		8,737	
10151	28		9,429	
10251	37		9,932	
11251	13		10,154	
10141	25			13,220
Sig.		1,000	,604	1,000

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = 15,228.

a. Uses Harmonic Mean Sample Size = 23,201.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

c. Alpha = ,05.

analysis (homogeneous subsets in Tables 6.8).

The students of DMPI (Dhaka Mohila (Women) Polytechnic Institute), code 10141, were found to be the best (class average point 13.22, slightly above the country average 9.27) among the five polytechnics that participated in the test in Bangladesh. This is the countries oldest women polytechnic, established in 1985, situated in the capital city of Dhaka, Bangladesh. A private polytechnic institute came second. Its class average points were 10.15. The country's oldest (1958) polytechnic institute, Dhaka Polytechnic Institute, was in 3rd position (class average point 9.93). Comilla Polytechnic Institute (code 10351), situated outside Dhaka, came last with a score of only 3.0.

Comparison of Inter School/ Class Performance: Germany

In Germany eleven (11) classes from seven (7) vocational schools participated the test. The results of the ANOVA test are presented in Figure 6.15.

In Table 6.9 the degrees of freedom (df), the F value, the significance of the F (Sig. p) and the partial eta squared (η_p^2) are given. The eleven classes in Germany differ with F value = 2.81 and the significance level p is 0.003. This large F ratio means that the variation among class-averages is more than it can be by chance.

These findings support that

Hypothesis H5 can be seen as accurate, particularly in the case of Germany. That means, in general

the trainee performance among vocational schools in Germany differs significantly.

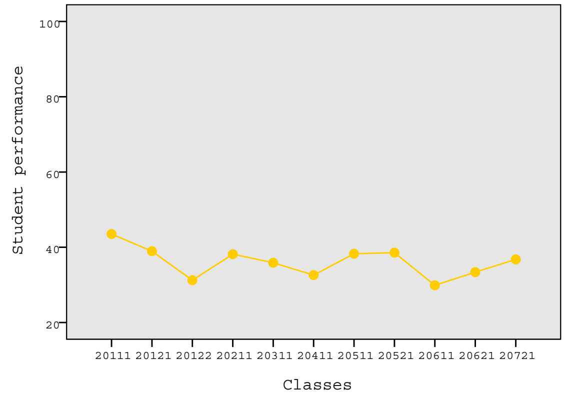


Figure 6.15.: Profiles of the class-averages of trainee performances in Germany.

Table 6.9.: The student performance differences between classes in Germany.

df	F	Sig. p	η_p^2
10, 149	2.81	0.003	0.159 ^{b}

b. R Squared = 0.159 (Adjusted R Squared = 0.102).

The *Student Newman-Keuls* test, was applied to make a posteriori pairwise comparison. The findings of this test are presented in Table 6.10.

Table 6.10.: Homogeneous subsets of different classes in Germany

Student-Newman-Keuls [a,,b,,c]

Class	N	Subset of classes	
		1	2
20611	13	29,885	
20122	16	31,250	
20411	16	32,594	32,594
20621	14	33,393	33,393
20311	9	35,889	35,889
20721	17	36,765	36,765
20211	12	38,167	38,167
20511	15	38,267	38,267
20521	13	38,577	38,577
20121	12	38,958	38,958
20111	23		43,500
Sig.		,323	,095

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = 97,141.

a. Uses Harmonic Mean Sample Size = 13,801.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

c. Alpha = ,05.

This test classified the eleven classes in Germany into two sub-sets: Subset 1 and Subset 2. As seen in Table 6.10 the performance between classes in Germany differs within this level between 29.89 (the lowest class average points) and 43.5 (the highest class average points). The difference between Subset 1 and 2 is significant too. For example, Class 20611 and 20122 in Subset 1 differ with Class 20111 in Subset 2 significantly. But, the trainee performance between classes within a subset was statistically not significant, considering a 5% significance level. For example, the observed significane level of Subset 1 is 32.3% (much larger than significance level 5%), that indicates that they do not differ significantly. Similarly, the observed significance level of subset 2 is 9.5% (larger than significance level 5%), that means, the classes within this subset do not differ significantly.

Discussion

Hypothesis H5 can only be confirmed from a general viewpoint. But, there are schools / classes whose performances are more or less similar (homogeneous subsets in Table 6.10).

It can be stated that *the trainee performances between vocational schools in Germany differ significantly (Hypothesis H5)*. But not all vocational schools differ from each other. Trainee performances of most of the schools participated, were found more or less similar ('post-hoc' analysis (homogeneous subsets in Tables 6.10).

Since the initial vocational training curriculum in Germany is flexible individual vocational school may put importance on different topic(s). The tasks set for the test were divided into the following subgroups: *Basic Electronics* (Task 1, 6 and 7), *Electronic Devices and Systems* (Task 8 and 9), *Electrical Power and Drive Controls* (Task 2, 12 and 13), *Sensors* (Task 4), *Industrial Communication* (Task 11), *Information Technology* (Task 5), *Programmable Logic Controllers* (PLCs)(Task 3 and 16) and *Machine Safety* (Task 14 and 15). Task 10 (carries 3 points) concerns about the *C Programming language*. It is not taught at any vocational school. Nearly all trainees obtained zero for this task and, therefore it is not included in this classification. A summary of the results (class average points with standard deviation) are presented in Table 6.11. The boxplots given in Appendix B.2.2, p. 188, show more details of the class performances in different task groups.

The two groups of trainees (BT: Electronics Technicians (Industrial Engineering) and GS: Electronics Technicians (Devices and Systems)) are analysed separately using ANOVA (analysis of variance). The class performances differ significantly in certain task-groups: BT classess differ significantly in task groups *Electronic Devices and Systems* (F = 2.75; df = 4, 67; p = .035) and *Sensors* (F = 6.61; df = 4, 67; $p < .001$). That means, these task groups are not equally of importance in all BT classess. The GS classes, on the other hand, differ significantly in task groups *Electrical*

Power and Drive Controls (F = 2.58; df = 5, 82; p = .032), *Information Technology* (F = 3.89; df = 5, 82; p = .003) and *Programmable Logic Controllers (PLCs)*(F = 4.92; df = 5, 82; p = .001).

Table 6.11.: Vocational school / class performance: task-group specific

Class	Basic Electronics (Max. 12)	Devices Systems (Max. 21.5)	Elec. Power & Drive Controls (Max. 12.5)	Sensors (Max. 8)	Industrial Comm. (Max. 6)	IT (Max. 6.5)	PLC (Max. 22)	Machine Safety (Max. 8.5)
BT1	4.2 (1.6)	4.7 (2.0)	5.5 (1.5)	4.5 (1.1)	1.8 (1.5)	1.9 (1.5)	10.9 (3.8)	5.3 (1.5)
BT2	3.3 (1.7)	2.1 (1.8)	4.2 (1.7)	2.7 (0.9)	1.8 (1.1)	1.5 (1.5)	10.7 (5.0)	5.0 (2.1)
BT3	3.8 (1.7)	4.8 (4.7)	5.9 (2.3)	3.9 (1.3)	1.0 (1.0)	2.1 (2.0)	10.9 (3.9)	**5.3 (3.0)**
BT4	3.5 (2.2)	2.8 (2.1)	4.6 (2.3)	**5.1 (1.1)**	1.4 (1.2)	2.0 (1.8)	9.0 (5.4)	5.0 (2.9)
BT5	4.4 (2.3)	4.4 (2.7)	4.9 (1.8)	4.0 (1.9)	**1.9 (1.7)**	1.5 (1.7)	10.4 (4.2)	**5.4 (2.3)**
GS1	**6.0 (2.2)**	**8.5 (3.7)**	**6.5 (1.9)**	4.8 (1.3)	1.1 (1.3)	**3.0 (2.5)**	9.6 (3.8)	4.0 (2.1)
GS2	5.0 (1.9)	7.7 (4.4)	6.2 (2.7)	3.7 (1.2)	1.6 (1.5)	0.8 (1.4)	8.6 (3.9)	4.3 (2.1)
GS3	3.8 (2.2)	6.4 (5.6)	5.2 (2.0)	4.4 (1.0)	0.6 (1.1)	1.3 (1.2)	**11.4 (3.9)**	2.7 (2.1)
GS4	5.3 (2.4)	7.9 (2.5)	5.1(1.6)	3.9 (1.4)	1.3 (1.3)	1.7 (1.7)	4.4 (3.5)	3.0 (2.5)
GS5	5.4 (2.7)	6.2 (3.8)	**6.5 (1.9)**	4.4 (1.1)	0.5 (1.1)	1.5 (1.5)	8.9 (5.3)	3.9 (1.8)
GS6	4.4 (1.6)	5.2 (2.8)	4.5 (2.2)	4.2 (1.1)	0.8 (0.9)	0.7 (1.3)	6.3 (4.5)	3.5 (2.2)

BT = Betriebstechnik (Industrial Engineering), GS = Geräte und Systeme (Devices and Systems)
Comm. = Communication, IT = Information Technology, PLC = Programmable Logic Controller
Lo (Std.Dev.) = The lowest average points within a task-group obtained by a class (standard deviation)
Hi (Std. Dev.) = The highest average points within a task-group obtained by a class (standard deviation)

As found in the competence test, the class performance differs among different task-groups. Hence, it can be assumed that, these performance differences are due to emphasising different learning fields – teachers can choose learning field freely and set different level of priorities because of flexible curriculum in the vocational schools in Germany.

Note:

The competence test results prove that the overall trainee performance of the two occupations: *Electronics Technician (Industrial Engineering)* and *Electronics Technician (Devices and Systems)* in Germany are comparable. They are comparable within the competence area of this technical competency test designed for this study. In Table 6.10 the class code number xxx11 / xxx12 is used for the classes of *Electronics Technician (Devices and Systems)* and the code xxx21 / xxx22 is for the classes of *Electronics Technician (Industrial Engineering)*. Both groups are almost equally distributed in both homogeneous subsets.

6.2.6. Student Assessment Approach in Bangladesh and Germany

Hypothesis H6: *The student assessment approaches in Bangladesh and Germany differ greatly regarding their theoretical requirements and practical relevance.*

The *Diploma-in-Engineering* programme intends to prepare Diploma Engineers with a qualification that corresponds to TVQF Level 6. At this level a Diploma Engineer should be in possession of a very broad range of “specialised, cognitive and practical skills” and “comprehensive actual and theoretical knowledge”, to be able to develop creative solutions to problems within a field of study or occupational activity (Moore, 2009, p. 11). BTEB envisages that the Diploma qualification should be regarded by other countries as well. The German Qualifications Framework (DQR) defines its Level 5, for example, as "be in possession of competences for the autonomous planning and processing of comprehensive technical tasks " (DQR, 2009, P. 10). The technical competence at this level encompasses "an extremely broad spectrum of specialised, cognitive and practical skills." The author assumes that TVQF Level 6 is equivalent to DQR[4] Level 5. However, the German Qualifications Framework for Lifelong Learning recognises the qualification of a person with the principle that "the important thing is what someone can do, not where he or she has learned to do it." ("wichtig ist, was jemand kann, und nicht, wo er es gelernt hat"). (DQR, 2009, p. 5). But in Bangladesh, the practical relevance of the curriculum content of the *Diploma-in-Engineering* programme of Bangladesh Technical Education Board (BTEB), particularly in the field of Electronics Technology, has being called into question.

A formal qualification is awarded to a candidate who has passed the final examination according to set standards/ criteria. In the following text the author investigates the student assessment approaches in Bangladesh and Germany in order to prove or disprove the above hypothesis.

The term "practical relevance" means in this scope of study whether the skills and knowledge that are assessed in the final examination are directly/ closely relevant to the future occupational tasks of a polytechnic student or a trainee, particularly in the field of electronics technology. In an interview with a professor and the head of the electrical and electronic engineering department of Technical Teachers' Training College the author has known that the BTEB curricular content is determined mainly on the basis of (philosophy and) introspection[5] strategy. This strategy is also reflected when the examination questions are prepared to assess students's performance.

In Bangladesh, the questions for the final examination are generally created by selected teachers who teach the particular subject. They are then reviewed by another group of (expert) teachers. That means, the participation of enterprises is lacking here, as is the case in determining the curriculum content. On the other hand, employers participation in preparing and/or reviewing question papers is achieved by including members from the chamber of commerce and industry in Germany. *These two different strategies of creating examination questions in Bangladesh and Germany indicate a big difference, in terms of theoretical and practical relevance.*

---

[4]DQR proposes eight reference levels, Level 1 to Level 8.

[5]"The introspection process basically consists of examining one's own thoughts and feelings about a certain area. However, within the context of curriculum content determination, this strategy may involve either an individual or a group". (Finch & Crunkilton, 1999, p. 140)

The layout and construction of test papers in Bangladesh are described in Section 5.2, where 60% of the items are very short and short type items. These items assess mainly students' knowledge of category Factual at level *Remember*. In fact, they are primarily theory relevant. For example, the syllabus for Electronics Technology includes the following subjects: 1) Microwave, Radar and Navigation Aids (MRNA); 2) Networks, Filters & Transmission Lines (NFTL); 3) Communication Engineering I & II (CE); and 4) Advanced Communication System (ACS). In this area (of communication technology), assessment items were found to be, for example:

Prove that $\frac{1}{\lambda^2} = \frac{1}{\lambda_p^2} + \frac{1}{\lambda_c^2}$, where the symbols bear conventional meaning; (Final Exam 2009, MRNA Q23; Final Exam 2009, MRNA Q21)

Describe the working process of the FMCW Radar with block diagram; (Final Exam 2009, MRNA Q24)

Derive the equation for the range of a RADAR; (Final Exam 2009, MRNA Q23)

Describe the construction in figure and working process of a reflex klystron tube; (Final Exam 2008, MRNA Q21)

Prove that $Z_0 = \sqrt{\frac{R+jwL}{G+jwC}}$ in the case of short length transmission line; (Final Exam 2009, NFTL Q25)

Draw the trunking diagram of an 1000-line telephone exchange and describe its working process. (Final Exam 2007, CE, Q22)

Describe the quantization method of PCM. (Final Exam 2009, CE, Q24)

The author finds that all the above listed assessment items are only theory relevant. These are generally taught at degree engineering level where mainly mastery / induction type curriculum is followed. These types of assessment items have not been seen in the German examination questions. The relevant curriculum content or the learning fields regarding these items can also not be found in the framework curriculum for vocational schools in the field of electronics technicians for devices and systems, or for industrial engineering.

Another area of the Diploma-in-Engineering (Electronics Technology) syllabus includes the subjects: 1) Programming in C, 2) Visual Programming, 3) Database Management, 4) Spreadsheet Analysis and Computer Operation & Word Processing. The student assessment items found in the examination questions are:

Write a Visual Basic programme to compute the real and non-real roots of a quadratic equation; (Final Exam 2009, Visual programming, Q12; Final Exam 2007, Visula programming, Q22; Final Exam 2006, Visual programming, Q23;)

Write a *Visual Basic* programme using function to compute the factorial of any positive number; (Final Exam 2007, Visula programming, Q25)

Write a programme to compute the first 10 Fibonacci numbers; (Final Exam 2007, Programming in C, Q23)
Write a programme using recursive function to compute the factorial of any positive number; (Final Exam 2007, Programming in C, Q22)
Write a programme to arrange ten numbers in ascending order. (Final Exam 2009, Programming in C, Q25)

A core area of the Diploma syllabus for electronics technology consists of 1) Microprocessors and Interfacing (MI), 2) Microcontroller and PLC (MC & PLC), 3) Computer Control System and Robotics (CCSR). The typical student assessment items found in the examination questions are:

Describe the robot system with block diagram; (Final Exam 2009a, CCSR, Q25; Final Exam 2009b, CCSR, Q21; Final Exam 2007, CCSR, Q23;)
Draw the block diagram of a Fuzzy logic controller; (Final Exam 2009a, CCSR, Q22)
Draw the block diagram of a PID controller; (Final Exam 2009a, CCSR, Q23; Final Exam 2009b, CCSR, Q24;)
Describe the working process of a PLC; (Final Exam 2009a, CCSR, Q21; Final Exam 2009b, CCSR, Q23)
Draw and describe the architecture of a PLC; (MC & PLC) Draw the internal architecture of a MC-6800 microprocessor (Final Exam 2007, MI-1, Q21)
Draw the pin diagram of a Z-80 microprocessor and write the functions of the pins (Final Exam 2007, MI-1, Q21)
Draw the pin diagram of a MC-68000 microprocessor and write the functions of the pins (Final Exam 2009a, MI-2, Q24; Final Exam 2008, MI-2, Q21)
Draw the pin diagram of a 80486 microprocessor and write the functions of pins (Final Exam 2009b, MI-2, Q24)
Draw and describe the internal architecture of an arithmetic co-processor; (Final Exam 2009a, MI-2, Q22; Final Exam 2009b, MI-2, Q22 ; Final Exam 2008, MI-2, Q22 ; Final Exam 2007, MI-2, Q23)

These are only a few assessment items. The author classifies these items mentioned above, as of type of ‘reproduction’, i.e. mainly theoritical. Almost all of the items in the examination questions of the last three years were found to be very similar. A complete examination question paper is shown in Chapter 4, Fingure 4.6. A detailed analysis of the question papers in Bangladesh has also been made in Section 4.4.3.

The findings of the examination papers analysis suggest that in Bangladesh test items are constructed to assess mainly theoretical knowledge in the category *Remember*, and in the category *Understand*. Assessment of student performance in the category *Apply* is only undertaken in a few cases. A classification of the items [(Bloom et al., 1956); (Anderson & Krathwohl, 2001)] has revealed that 51.0% of the items on an average are of the cognitive process category *Remember*, 43.9% are of the category *Understand*, and only 5.1% are of the category *Apply*. This data implies that the assessment items are mainly theoretical.

On the other hand, the examination questions for the vocational school trainees in Germany are mostly practical relevant. They primarily demands trainees' skills and knowledge at the cognitive process categories that are higher than 'reproduction'. Some questions used to assess the trainees in vocational schools in Germany are shown in Figure 6.16 to 6.18.

6.4 Ein Kunde fragt Sie nach Möglichkeiten, seine drei Rechner ohne Kabelverlegung miteinander zu vernetzen. Es soll auch jederzeit möglich sein, sich mit einem zusätzlichen Laptop in das Netz einzuklinken, ohne dass einer der drei fest installierten Rechner eingeschaltet ist, um z. B. den Internetzugang zu nutzen.
Beraten Sie den Kunden hinsichtlich

6.4.1 der erforderlichen Hardware.

6.4.2 der in der Praxis erzielbaren Übertragungsgeschwindigkeit.

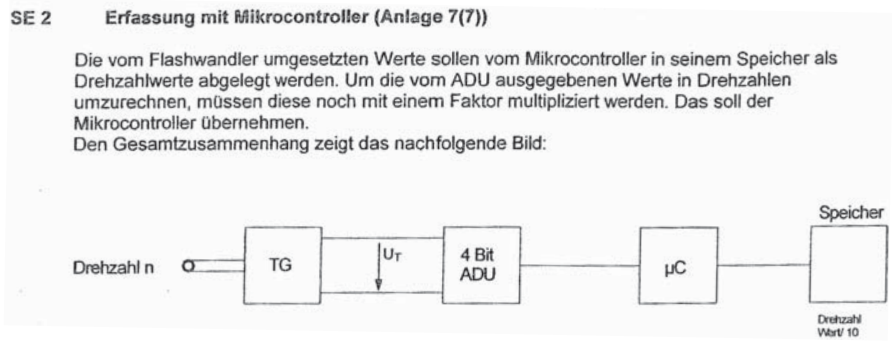
6.4.3 erforderlicher Schutzmechanismen, um das Netz bestmöglich vor Zugriffen Dritter zu schützen.

Figure 6.16.: A task used to assess trainees' IT competence in Germany. (Source: Winter 2008 / 09 Berufstheorie II, FS 6, p. 5.)

The task in Figure 6.16 describes that three personal computers (PCs) and a laptop should be networked without cable. That means the task is about installing and configuring an wireless LAN. It includes three assessment items: necessary hardware, maximum possible data rate in practice, and the data security. Such IT technology related questions were absent in the question papers in Bangladesh. Instead, Polytechnic students were assessed for whether they can draw, name and describe the functions of each pin of a pentium processor, for example.

The task in Figure 6.17 is about designing a microcontroller based system and a programme for data acquisition. An open table was supplied with this task as appendix (not included in this dissertation). The assessment items were as listed below the Figure 6.17.

For an electronics technician this task is relevant to his or her future workplace in the relevant occupation. Instead of assessing these types of skills, polytechnic students in Bangladesh are assessed upon their knowledge of the internal architecture (Q24), the basic block diagram of



SE 2 Erfassung mit Mikrocontroller (Anlage 7(7))

Die vom Flashwandler umgesetzten Werte sollen vom Mikrocontroller in seinem Speicher als Drehzahlwerte abgelegt werden. Um die vom ADU ausgegebenen Werte in Drehzahlen umzurechnen, müssen diese noch mit einem Faktor multipliziert werden. Das soll der Mikrocontroller übernehmen.
Den Gesamtzusammenhang zeigt das nachfolgende Bild:

Figure 6.17.: A task used to assess trainees' competence in the area of microcontroller based system in Germany. Source: Sommer 2009 Berufstheorie I, SE 2, p. 6.

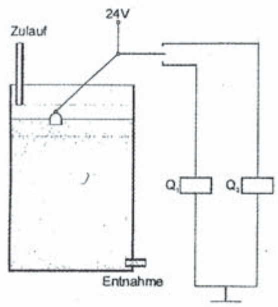
SE 2-Q2.1	Complete the table given in appendix.
SE 2-Q2.2.1	By which factor must the digital value be multiplied?
SE 2-Q2.2.2	How can you process this multiplication by a microcontroller, when you should avoid multiplication and division instructions?
SE 2-Q2.3	why is it enough to store the speed (Drehzahl) divided by a factor of 10 in memory?
SE 2-Item 2.4	Draw an flowchart to store the speed. At every 100 ms a new speed value should be read. The sub-programme "TimeDelay100ms" is available for you. The ADC (ADU) is connected to 4 lower pins of PORT 1. The speed should be stored to an external memory (start address 0100H).

a microcontroller (Q25), pin diagram (Q21), addressing mode (Q22), etc. (Final Examination Question 2010 and 2009, Microcontroller & PLC). The task shown in Figure 6.18 is about developing an application programme using a small PLC for an automatic water reservoir. Diploma-in-Engineering students were asked to draw and describe the PLC architecture (Q24), the PLC memory organization (Q25), the rules on how to draw a ladder diagram (Q22)(Final Exam 2010 and 2009, Microcontroller & PLC), or to draw the national flag of Bangladesh (Final Exam 2007, Programming in C, Q25).

A detailed analysis of the question papers, used for the final examination for initial vocational training in Germany, is made in Section 4.5.2. It has been found that the items are closely relevant to the work in the real world. This argument can be further supported by the findings of the examination questions analysis. Here only 7.5% of the total items in the final examination questions could be classified in the category *Remember*, whereas 23.7%, and 32.6% are in the category *Understand*, and in the category *Apply*, respectively and in the category *Factual and Conceptual knowledge*. In the category *Procedural knowledge* the percentage of total items in three different cognitive process categories are 0.4, 2.6, and 33.3, respectively. On an average, 65.8% of the test items were of the category *Apply*, 26.3% were of the category *Understand*, and only 7.9% were of the category *Remember*, according to Bloom's (1956) taxonomy.

SE 5 Automatisiertes Wasserreservoir

Ein Regenwasserbehälter erhält Zulauf aus der Regenrinne und besitzt eine Entnahme. Es soll nun eine Erweiterung der Anlage erfolgen, sodass immer eine Mindestmenge an Wasser verfügbar ist. Hierzu wird mit Hilfe einer Pumpe Wasser aus einem unterirdischen Behälter zugeführt. Die Ansteuerung der Pumpe erfolgt automatisch. Es wurde ein Schwimmer als Sensor eingebaut, der einen Wechselschalter bedient. Die Schaltkontakte wirken dabei wie Taster, die jeweils nur in den Endlagen zu einer Betätigung führen.



5.1 Zeichnen Sie eine VPS-Schaltung (Schützschaltung), mit der die Pumpe angesteuert werden kann.

5.2 Fügen Sie weitere Taster ein, mit der die Pumpe zusätzlich von Hand betreiben werden kann.

5.3 Die Schaltung soll nun mit einer Kleinsteuerung realisiert werden.
Erstellen Sie das Programm für die Kleinsteuerung.

5.4 Handelt es sich bei der Schaltung um eine Steuerung oder um eine Regelung?
Begründen Sie Ihre Aussage.

Figure 6.18.: A task used to assess trainees' competence in the area of PLC controlled system in Germany. Source: Sommer 2009 Berufstheorie II, SE 5, p. 5.

The bar graph in Figure 6.19 shows the percentage of student assessment items in different categories used in the Diploma-in-Engineering final examinations in Bangladesh and in the apprenticeship vocational training in Germany, over the last three years. A t-test was used to compare the average values of the three different categories between Bangladesh and Germany. The results are given in Table 6.12.

Categories	t	df	p
Remember	5.57	22	$< .001$
Understand	3.41	20.56	.003
Apply	-14.18	7.33	$< .001$

Table 6.12.: A comparison of assessment items between Bangladesh and Germany using t-test

However, a "majority of test items are in the category *Apply*" may not automatically mean that they are "practical relevant". But the test items in Germany are created based on the concept of the learning field which focuses mainly on practical relevant content. Moreover, the author conducted a test in Bangladesh and Germany. The practical relevant items were included in this test primarily. Items were examined and validated upon their practical relevancy by

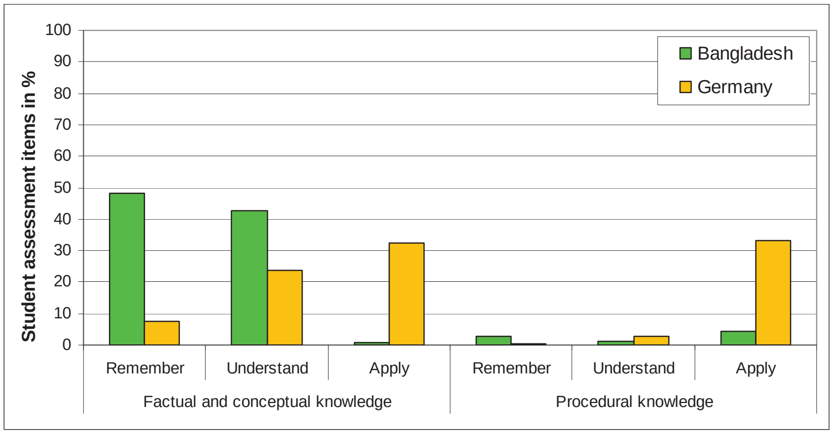


Figure 6.19.: Categories of the assessment items used for the final examination in Bangladesh and in Germany

expert teachers. For example, they graded 75% of the tasks as "highly practically relevant". Bangladeshi teachers estimated the probability that their students would solve the tasks correctly as "very low". Their comment was "we assess our students differently". They refused to conduct the competency test at the beginning on those grounds. The statistical data of the teachers' assessments are given in Appendix B.

Both the qualitative and the quantitative analysis, therefore, prove that the differences in student assessment items vary to a great degree in terms of theoretical and practical relevance.

Thus, Hypothesis H6:
The student assessment approaches in Bangladesh and Germany differ greatly, regarding their theoretical requirements and practical relevance.
could be proved to be correct.

Polytechnic students are assessed mainly for theoretical knowledge in Bangladesh. On the other hand, mainly practical relevant skills and knowledge are focused upon in Germany when trainees are assessed.

7. Reform/Modernisation Proposal

7.1. Reform of the Current Curriculum

The curriculum for the *Diploma-in-Engineering (Electronics Technology)* has been analysed. The outcome (students' competency level), particularly in the case of application oriented tasks, was measured through a competence test. In this competence test polytechnic students came off badly and lag far behind the vocational school trainees in Germany. A comparison of the findings in Bangladesh and Germany, as presented in this research, reveals that the difference in the students' performances can be explained by the differences in the two countries' curricular areas of emphasis and different focuses in their respective curricula. The *Diploma-in-Engineering* curriculum in Bangladesh covers a broad spectrum of curriculum content and focuses mainly on theoretical matters. In Germany the curriculum is relatively specialised and it emphasises practical tasks.

Hence the need for a reform in the *Diploma-in-Engineering (Electronics Technology)* curriculum in Bangladesh is more than obvious. A transition from current subject based to learning field based curriculum, as in Germany, will require a detailed study. The introduction of the competency based training (CBT) approach at Diploma level will also require a feasibility study, as was recently carried out for countries in Mekong region (Cambodia, Laos, Thailand Vietnam) by Xaymountry (2009).

In the following sections some findings in this study are summarised and some curricular improvements and changes for the *Diploma-in-Engineering (Electronics Technology)* curriculum in Bangladesh are proposed.

7.1.1. The Strengths of the Current Curriculum

The content of the curriculum covers a wide range of areas including domain specific subjects; cross-occupational subjects (e.g. information technology, biomedical engineering, communication technology, engineering drafts); and related subjects (a high level of mathematics, natural science, social science, business studies, entrepreneurship, environmental engineering, etc.).

The curriculum (syllabus) is detailed and well documented. This facilitates all polytechnic institutes in Bangladesh to follow the same curriculum content, and therefore the student performance of all polytechnics is expected to be more or less the same, or comparable, given other factors. Although the duration of the course has been found to be relatively longer, compared to Germany's initial apprenticeship training programme, students absolving this course may be better prepared for their future workplace with this longer period, if they use it effectively.

7.1.2. The Weaknesses of the Current Curriculum

An occupational profile (working fields, duties, etc.) and occupational standards for electronics technicians, which are the basis for a systematic curriculum content determination, are missing. It has been found in the analysis that the percentage of technical content and related subject content in terms of allocated credits are: c. 55% and 41%, respectively, and c. 4% for the enterprise attachment training. This data shows that the *Diploma-in-Engineering* curriculum in Bangladesh is a combination of general education and TVET curricula. The points below illustrate some of the weaknesses of the current curriculum:

Didactic reduction: One of the main weaknesses of this curriculum is that only little, or in some cases practically no value has been attributed to the principles of didactic reduction in the design and delivery of the curriculum. For example, in Applied Mathematics II, one of the defined four aims (general objectives) is: *"to use the knowledge of Laplace transformation to solve the boundary differential equations and to find the impedance and reactance of the electric circuit"* (5th semester syllabus, p. 38). Laplace transformation is taught at University level. In most cases in mathematics, communication engineering, etc. students are asked to derive complex formulas that are usually taught at University level.

Harmonisation between technical subjects and related subjects: A good level of harmonisation (in terms of relevance) among the technical subjects and related subjects is missing too. For example, within the related subjects (which make up 41% of the total credits of the programme), five mathematics courses (total 17 credits) are taught from the 1st to the 5th semester. Out of these five courses, three are general mathematics, namely Mathematics I, II and III, the other two are called Applied Mathematics I and Applied Mathematics II. Most of the content found in the syllabuses titled "Applied Mathematics" is "not applied" at all. Because, *firstly*, the same content in Applied Mathematics I, for example, is taught in *Diploma-in-Engineering (Architecture Technology)*, *Civil Technology* and also in *Electronics Technology*. Students of all technologies

(Architecture, Civil, Electronics, etc.) are assessed using the same examination question paper. *Secondly*, most of the content of applied mathematics has no applications in the field of electronics technology. For example, in Applied Mathematics II, one of the defined four aims (general objectives) is: *“to be able to use the knowledge of differential equation to solve the problems of hydrodynamics and velocity of a particle in space”* (ibid.). The author does not think that this objective is in line with electronics technology at Diploma level. Curriculum content such as De Moiver’s theorem (i.e. Find the complex roots applying De Moiver’s theorem of the types:
i) $x^7 + 1 = 0$, ii) $(1 + i)^{\frac{1}{3}}$) (4th semester syllabus, p. 66), Green’s theorem, Stokes’s theorem, Beta function, Gamma function, etc. have no application in the area of electronics technology at Diploma level.

Subject (re)organisation: Teachers complain that in some cases they have to teach or explain the relevant mathematics while they teach technical subjects, because these relevant mathematics are taught later than they are required. This was confirmed during the curriculum content analysis. For example, a mathematical topic such as *Fourier series* is taught in 4th semester, but students require this concept in electrical circuits and signals / waveforms analysis, for example, a / c circuits, modulation / demodulation techniques, etc., which are taught in 2nd and 3rd semesters. In the current syllabus both of the applied mathematics courses (Applied Mathematics I and II) are taught in 4th and 5th semester, respectively. Therefore, technical subjects, related subjects and enterprise attachment training should be arranged in relation to each other.

Practical relevance: As mentioned earlier, polytechnic students in Bangadesh (Section 5.1.1, p. 93) and also vocational school trainees in Germany (Section 5.1.2, p. 93) participated in a competence test that measured students’ / trainees’ competencies in solving practical relevant tasks. The assessment items of this test included tasks from several core areas of the electronics technology such as basic electroncs, electronics devices & systems, PLCs, IT, sensors, drives and machine safety, etc. The test papers are given in Appendix A, p. 172. The test results, however, show that polytechnic students do not acquire satisfactory knowledge and skills in these areas.

For example, according to curriculum polytechnic students are taught the working principle and functions of an operational ammplyfier, working principles of Wheatstone bridge and sensors (e.g. strain-gauge). Task 7 of the competence test require the knowledge and skills of these three basic elements together. Poytechnic students obtained only 0.4 out of 6 points on an average. Similarly, polytechnic students are taught diodes, transistors, relays, etc. But they do not know how to control (on / off) a relay based output of an electronic device (Task 8). Programmable logic controllers (PLCs) are taught at polytechnics, but it seems to be limited to only description of it and drawing its memory architechture. Task 16 assessed whether students can use PLCs to control a drive for an elevator. No Bangaldeshi students could solve this task, whereas vocational trainees obtained 5.2 (country average) out out 14 points. The performance of Bangladeshi polytechnic students and also German vocational school trainees in individual tasks can be seen in Appendix B.2, p. 187.

This findings and the curriculum content analysis prove that the main focus of the *Diploma-in-Engineering (Electronics Technology)* curriculum is not placed upon the practical requirements, but rather on theoretical matters. Basically TVET is concerned with the acquisition of knowledge and skills for the world of work. Since teachers strictly follow the syllabus and deliver the content that is mainly theories and principles, and students also learn them to pass the examinations, the curriculum focus must be shifted towards the practical relevancy, if the polytechnic graduates are to be prepared for the world of work, so that they can compete at national and at international level.

Enterprise attachment/ training: Polytechnic students are placed with companies for a period of 16 weeks (including 4 weeks at polytechnics), only 13.3% in total, for their work experience. This is a very short period compared to Germany's initial vocational training in the Dual System. Here trainees spend 74.3% of the total duration of the training programme in enterprise training. Moreover, the enterprise attachement training in Bangladesh is neither well managed nor efficient. The author experienced this when interviewing students and teachers in Dhaka, Bangladesh. For example, during the six month period of the 7th semester students undergo 12 weeks of training at enterprises, and 4 weeks at their respective polytechnic institute laboratory/ workshop. Students are kept waiting for a period of two months time, until the 8th semester begins. That means, 38.46% time is unused in this semester (note: one semester = 26 weeks).

7.1.3. The Inert Content

It is hard to differentiate, whether some particular contents are workplace relevant or not. This assessment is subjective. However, in the *Diploma-in-Engineering (Electronics Technology)* syllabus there exist some contents that are certainly only theory. It is highly probable that knowledge of these kinds of content will not be applied by the graduates at their future workplace. These kinds of content are termed "inert contents", and the student's knowledge in this is known as "inert knowledge". The following is a list of such inert contents, among others: technical subjects: 32, 64-bit microprocessors (Intel 80286, 80386 and 80486 microprocessor), dynamic RAM controller, direct memory access (DMA) and DMA controlled I/O & arithmetic co-processor, Programming with Visual Basic (Code 2659), ; mathematics: De Moiver's theorem, Greens theorem; divergence theorem and Stokes's theorem, special types of integration, Beta function and Gamma function of definite integrals; modern physics: atomic structure, wave properties of particles, quantum mechanics, solid state, nuclear transformation, simple harmonic motion, sound and light; et cetera.

7.1.4. The Curriculum Content that may be Discarded

The *Diploma-in-Engineering (Electronics Technology)* curriculum includes a wide range of subject-matters. Some subjects are taught at university level. The author thinks that the polytechnic students are overburdened. However, in order to bring the main focus on the practical relevance matter, and not to (further) overburden, some contents must be discarded. Initially, the author suggests to discard the 'inert content' listed in Section 7.1.3, p. 152. A committee consisting of experts and teachers should decide about it.

7.1.5. The New Curriculum Content that maybe Included

The competence test included tasks (assessment items) from different areas that are particularly important for an occupation in the field of electronics technology. Teachers assessed that some particular tasks (e.g. Task 11) are not in the syllabus. Students' performance in these particular tasks also proves that the content related to these tasks was not taught in the classroom nor in enterprise training.

Moreover, in this study the author reviewed the curriculum content. Job vacancy announcements (from employers' websites, job-center data bank, etc.) were also analysed in order to get the current market requirements. Therefore, for the *Diploma-in-Engineering (Electronics Technology)* course some new contents are suggested that will contribute to meeting the current job market requirements. They are, for example: industrial communication buses such as RS485, controller area network (CAN) bus, process field bus (PROFIBUS DP and PA), Industrial-Ethernet, PROFInet, actor sensor interface (ASI) bus, etc.; data buses such as SATA, HDMI, Displayport, MIPI; Industry-PCs (IPCs); AVR-ATmega microcontroller; Soft-SPS (e.g. CoDeSys, an IEC-System); software development environment (Entwicklungsumgebung) such as Batronics, Keil, etc.; JAVA / C++ programming language (instead of Visual Basic); LINUX OS, Networking (LAN, WLAN) with LINUX; embedded systems design and programming; machine safety (Emergency STOP function); electrical safety rules and regulations; protective measures; etc.

7.2. Reform of the Student Assessment Approach

An investigation in this study found that polytechnic students are assessed mainly for theoretical knowledge. 20% of the assessmet items are very short type of questions, 40% of the assessmet items are short type of questions. These short (objective) type of questions assess only students' discrete knowledge of type *Remember*. The rest 40% of the question items are descriptive but they assess mainly students' theoretical knowledge (block digram, pin diagram, working principles, etc.). The competence test results of Bangldeshi polytechnic students clearly show that less emphasis is placed on practical relevant skills and knowledge when they are assessed in the final examination. This approach of student assessment in Bangladesh differs greatly compared to that in Germany. The differences in student / trainee assessments in the final examinations between Bangladesh and Germany are explained in Section 6.2.6, p. 141.

The author, therefore, suggests that student assessment items (examination questions) should place emphasis on measuring the competences that will be required to solve tasks relevant to the students' future profession. These practices will motivate students to learn those competences and the teachers to focus upon the subjects relevant to these tasks. Therefore, a change in the current student assessment approach, for example inclusion of problem-oriented and 'real' situation oriented tasks in examinations, is urgent.

Furthermore, in some cases, it was found that the same question paper is used to assess students of several different technologies. For example, the same examination paper for *Programming in C* was used (Final Exam 2009) to assess students of Civil, Electronics, Mechanical, Survey, Garments Design and Patter Making Technology. This practice should be changed, because students of electronics technology should be assessed to test if they can use *C programming language* to programme a microcontroller, for example. The assessment tasks in the examination should be relevant to the respective technology and application oriented, particularly for TVET courses.

The competence test results also showed that polytechnic students' had a lack of competences in reading data sheets and in using the given information in it to solve tasks (Task 9 and 15 for example). Using Handbooks / engineers' reference books in the examination, as they are used in Germany, may facilitate the students to use information of the category *Remember/Retrieval*. This should be practiced in the classroom and laboratories as well. Thus, students will get used to transferring technical data / information and applying them to solve tasks. These practices will improve students' competency particularly in designing, developing, installing and configuring new devices and systems.

In order to improve students' fluency in professional English at least some (open) questions are to be in English in each examination. Students must answer these questions in English. These questions will not only assess students' technical knowledge but also their competencies in professional English. This strategy will motivate students to read English text / reference books.

7.3. The Qualification Deficits

The curriculum content analysis, examination questions analysis, and the results of the competency test clearly indicate that a qualification gap exists between the workplace requirements and the qualifications / competences which the current Diploma-in-Engineering (Electronics Technology) curriculum can offer.

This study identified that polytechnic students lack, in particular the ability to transfer / use skills and knowledge required to solve comprehensive technical tasks (e.g. Task 8, Task 16, and also other tasks); basic skills such as reading data sheets and using the information accordingly (e.g. Task 9 and 15), English language competence – polytechnic teachers refused to conduct the competence test in this study at the beginning on the ground that students were not competent in reading English language test papers. Later, however, a translated Bangla version of the test was supplemented together with the Englisch version. The competecy test results also prove that polytechnic students have huge deficiencies in domain specific technical skills and knowledge (Task 3, 11, 14, for example).

Some of the most required competences found from a review of job advertisements (e.g. employment agency's data bank, the Internet, newspapers, etc,) are: communication skills, people management, team skills, customer service skills, results-orientation, problem-solving. To identify the qualification requirements and deficits for electronics technicians further study is required.

7.4. TVET Programme Monitoring: Central or Distributed?

The findings of the competency test revealed that in general the performance of the Dhaka (the capital) based polytechnics were better compared to that of the polytechnics situated outside Dhaka, although all polytechnics follow the same curriculum.

Investigations are needed to find out the influence of TVET monitoring system on the performance of polytechnic institutes, given other determining factors.

8. Conclusion and Future Work

8.1. Results of Hypotheses Verification

Hypothesis H1 states: *The competency level, in the case of application-oriented tasks, achieved by the polytechnic students/graduates in Bangladesh at the end of the Four-Year Diploma-in-Engineering course is lower than that of the vocational school (Berufsschule) trainees in Germany at the end of the Three-and-One-Half-Year Apprenticeship Training in the Dual System.*

Summary of the findings (p. 119 ff.):
Hypothesis H1 was proved positive.

The measured competency level of polytechnic students in Bangladesh was found to be only one fourth of that of vocational school trainees in Germany. These findings support the experts and employers' doubts about the competencies of polytechnic graduates, particularly in the case of practical relevant tasks.

The test covered different areas of the syllabus: basic electronics, devices and systems design, programmable logic controllers (PLCs), sensors, basic electrical circuits and power, electrical drive controls & safety measures, industrial communication, IT, etc. However, Bangladeshi polytechnic students could not show better or equal performance in any of these areas.

Hypothesis H2 states: *The tasks, which require only knowledge reproduction, are solved correctly with a higher probability than the tasks, which require higher level cognitive processes.*

Summary of the findings (p. 125 ff.):
Hypothesis H2 can only be confirmed in comparison between the categories *Remember* (reproduction) and *Apply* (transfer). Students and trainees showed similar performance levels in both categories *Remember* (reproduction) and *Understand* (re-organization).

The students' / trainees' competence level in the category of *Apply* was much lower than the competence levels in other two categories: *Remember* and *Understand*.

Due to the fact that in general the vocational school trainees in Germany enjoy a different learning environment / situation than the polytechnic students in Bangladesh, this particular investigation has led to the following hypothesis (H3).

Hypothesis H3 states: *In answering the tasks that demand mainly higher level cognitive processes, the performance level differs notably between the polytechnic students in Bangladesh and vocational school trainees in Germany.*

Summary of the findings (p. 127 ff.):
Hypothesis H3 could be proved.

The performance differences at the level *Apply* and also at level *Understand* between the polytechnic students in Bangladesh and the vocational school trainees in Germany are very significant and notably bigger than the performance difference at level *Remember* between these two countries.

This is justified by the curriculum / student assessment analysis that shows that the Diploma curriculum mainly focuses on theoretical matters. The findings of the examination questions analysis clearly indicate that only little emphasis is placed on transfer-based tasks in Bangladesh compared to Germany. Trainees in Germany undergo enterprise training much longer than polytechnic students in Bangladesh, they practice application oriented tasks there too. Moreover, the main focus of the learning field based curriculum in vocational schools in Germany is practice-oriented learning and teaching, with the emphasis on transfer based tasks in a particular occupation.

Hypothesis H4 states: *The teachers are in a position to estimate the ability of the students to solve the tasks they are set.*

Summary of the findings (p. 132 ff.):
Hypothesis H4 could be confirmed.

But in general, teachers estimations were higher than their students' actual achievement. Therefore, it can be said, *"In most cases, the teachers are able to estimate the difficulty of the tasks in relation to the others, but they overestimate students' achievement."*

Hypothesis H5 states: *The student performance between schools/ classes differs significantly.*

Summary of the findings (p. 136 ff.):
Hypothesis H5 was proved.

It could only be confirmed from a general viewpoint though. Because not all polytechnics/ classes in Bangladesh differ from each other. Some polytechnics showed more or less a similar level performance. Polytechnics situated in the capital city Dhaka showed better performance than those situated outside the city.

Similarly, in Germany the trainee performance among vocational schools differs, in general, significantly. However, many vocational schools that participated in the test showed nearly similar performance.

Hypothesis H6 states: *The student assessment approaches in Bangladesh and Germany differ greatly regarding their theoretical requirements and practical relevance.*

Summary of the findings (p. 141 ff.):
Hypothesis H6 was proved to be correct.
In Bangladesh polytechnic students are assessed mainly for theoretical knowledge. On the other hand, mainly practical relevant skills and knowledge are focused upon in Germany when trainees are assessed.

8.2. Further Discussion and Future Work

8.2.1. Further Discussion

The curriculum of the *Four-Year Diploma-in-Engineering (Electronics Technology)* course was analyzed and the students' competence, particularly in the case of tasks relevant to practical application, was empirically measured. Both, the Diploma curriculum and the measured student performance were compared with Germany's initial vocational training curriculum and vocational school trainee performance. Investigation was also carried out to find out whether teachers are able to estimate the ability of their students to solve tasks. Furthermore, it was examined if students' performances differ among institutes/ schools/ classes.

This empirical study found that the differences between the two countries lie not only in the curriculum (content, organisation, etc.) or the TVET systems, but, most importantly, the curriculum focus. The full-time school based TVET system of Bangladesh follow subject based curricula and provide qualifications based on student assessment that is mainly (or only) theoretical. The results of the competency test reflected this differences. Polytechnic students in Bangladesh could not achieve a competency level that is comparable to the competency level of vocational school trainees in Germany.

However, this unexpected performance of polytechnic students can be explained as follows:
1) Students have got used to dealing with specific tasks relevant to the examinations which recur on a regular basis. That means, if a student has learnt to deal with examination tasks that had been repeatedly tested within the last three to five years, he / she can pass the examination with good points. But most of the task used for the competency test in this study simulated real world problems, but for the polytechnic students they were so called “uncommon tasks”.

2) The development of student competence is influenced by many other factors such as the (domain specific) prior knowledge, key competences (literacy, numeracy) and, to a much smaller extent, the quality of training at enterprises and schools (Nickolaus, 2010, p. 6).

3) The Diploma curriculum for electronics technology covers a wide range of cross-occupational knowledge and skills. For example, domain specific subjects include, among other (core) subjects: Biomedical Engineering; Communication Engineering; Advanced Communication Systems; Microwave, Radar and Navigation Aids; Monochrome Television Engineering; Color Television & Video Systems; Multimedia and Graphics; Visual Programming; etc. The competency test in this work covered the core areas of basic electronics; microcontrollers and programmable logic controllers (PLCs); electrical power, drive controls, and machine safety; sensors; information technology, etc., not the cross-occupational subjects. That means, the anomalies in occupational profiles and the curriculum content between countries make it difficult to compare students’ competencies at international level. Moreover, any vocational curriculum has measurable and unmeasurable outcomes.

4) 30.6% of all the lesson hours are occupied by mathematics, natural science and other related subjects, whereas in Germany it is about 9%, excluding mathematics. It is included with domain specific subjects.

5) Other issues involve economic, social and, ultimately, political (e.g. political unrest and students’ involvement with politics, among others) issues, and also to the relations between education and work.

8.2.2. Future Work

The empirical findings of this study have revealed that there are huge shortcomings of the current *Diploma-in-Engineering* programme outcomes. Many subject experts and teachers in Bangladesh take the view that the present *Diploma-in-Engineering* curriculum is of too high a standard in the sense that much of its contents is taught at Degree level. Moreover, there is a commonly expressed belief that institution-based courses too often emphasize theoretical or 'book' knowledge at the expense of the ability to apply knowledge to perform practical tasks and to fulfil workplace roles [(Humphrey, 1992, p. 61); (Tuxworth, 1989); (Jessup, 1989., p. 66)]. A study of the *Diploma-in-Engineering* syllabus and the university syllabus in this research work has shown that some of the current contents of the *Diploma-in-Engineering* course are repeated at the university level which supports the teachers' opinion stated above. The study also shows that some curriculum contents are not relevant or very less relevant to the particular occupation and / or to the real world of work (irrelevancy). Therefore, a field level investigation (e.g. task / job analysis) is required in order to confirm the workplace-relevance of the current curriculum. In particular, the relevance of curriculum content (attributed by students / trainees) is of great importance (Geißel, 2008).

Investigation on students' qualily at input stage (e.g. prior knowledge, qualifications, etc.), the quality of training (e.g. TVET curriculum delivery processes / methods, instructional and learing materials, supplies and laboratory equipment, teaching personnel etc.) are also required. Research for the other related TVET occupations will certainly contribute to the improvement of a particular occupation.

It was found from curriculum analysis that the *4-Year Diploma-in-Engineering* programme has a total of 4800 lesson hours (one lesson hours = 50 minutes), whereas Germany's Three-and-One-Half-Year Apprenticeship Training in the *Dual System* has 6064 lesson hours. In both cases the enterprise attachment training period is included. Therefore, an investigation of the current *4-Year Diploma-in-Engineering* programme for its effectiveness and efficiency is necessary. While the competency test was conducted the author came across that polytechnic students undergo 12 weeks training at enterprises and 4 weeks at polytechnic institutes and then they wait for 2 to 3 months until the 8th, and also the last semester begins.

At this moment there are no formally defined aims and objectives for the training occupations in Bangladesh. These must be defined first of all. It is to be noted here that the technical and vocational education and training (TVET) is concerned with the acquisition of knowledge and skills for the world of work (UNEVOC (2010)) and "the TVQF Level 6, the Diploma level, is the premier TVET qualification and it is at this level that the future of Bangladesh competitiveness in the world is dependent on. It is this level that made Singapore what it is today" (Moore, 2009, p. 10).

Bibliography

Albers HJ (2001) *Modelle und didaktische Konzepte in der Berufsbildung. In: Bonz, B. (Hrsg.): Didaktik der beruflichen Bildung. Berufsbildung konkret Band 2.* Baltmannsweiler: Schneider-Verlag Hohengehren.

ALIS (2009) Alberta Occupational Profiles – Curriculum - Electronics Engineering Technologist. Website. Accessed: 7 July 2010.
URL http://alis.alberta.ca/occinfo/Content/RequestAction.asp?aspAction=GetHTMLProfile&format=html&occPro_ID=71002451&SNT_ID=25

Anderson LW, Krathwohl DR (2001) *A Taxonomy for Learning, Teaching, and Assessing.* Addison Wesley Longman.

Artelt C, MacElvany N, Christmann U, et al. (2005) *Expertise Förderung von Lesekompetenz (Bildungsreform No. 17).* Berlin.
URL www.mpib-berlin.mpg.de/en/forschung/eub/projekte/bekl.html

Atherton JS (2009) Learning and Teaching: Curriculum. Website. Accessed: 8 May 2010.
URL http://www.learningandteaching.info/teaching/curriculum.htm

Bader R (2002) Handlungsorientierung in der Berufsbildung: Variantenreiche Ausprägungen. *In: Die Berufsbildende Schule* **54. Jg., H. 3**:S. 71–73.

Bader R (2003) Lernfelder konstruieren - Lernsituationen entwickeln. *In: Die berufsbildende Schule* **55**(7-8):213.

Bader R (2004) *Handlungsfelder - Lernfelder - Lernsituationen. In: Bader, Reinhard; Müller, Martin (Hrsg.): Unterrichtsgestaltung nach dem Lernfeldkonzept*. Bielefeld, Bertelsmann Verlag.

Bader R, Müller M (2002a) Leitziel der Berufsbildung: Handlungskompetenz. *Die Berufsbildende Schule* **54. Jg.**(H. 6,):S. 229–234.

Badley G, Marshall S (1995) *53 Questions and Answers about Modules and Semesters.* Bristol: Technical and Educational Services, Cromwell Press Ltd.

Baethge M, Baethge-Kinsky V (1995) *Ökonomie, Technik, Organisation: Zur Entwicklung von Qualifikationsstruktur und qualitativem Arbeitsvermögen. In: Arnold, Rolf/Lipsmeier, Antonius (Hrsg.).*

Bailey T (1990) Jobs of the Future and the Skills They will Require. *American Educator 14* (1):10 – 15, 40 – 44.

BANBEIS (2010) Bangladeh Bureau of Educational Information and Statistics (BANBEIS). Online. Url = http://www.banbeis.gov.bd/ db_bb/technical_education.htm.

BBC (2010) BBC Country Profile - Bangladesh. Online. URL `http://news.bbc.co.uk/2/hi/europe/ country_profiles/1160598.stm #facts`

BBT (2010) Das Bundesamt für Berufsbildung und Technologie (BBT). Online. URL `http://www.bbt.admin.ch/themen/berufsbildung/index.html?lang=de`

Becker M, Spöttl G (2008) *Berufswissenschaftliche Forschung. In: Falk Howe and Georg Spöttl: Berufliche Bildung in Forschung, Schule und Arbeitswelt*, vol. Band 2. Peter Lang, Frankfurt am Main.

BIBB (2009) Liste der staatlich anerkannten Ausbildungsberufe. Online. URL `http://www2.bibb.de/tools/aab/aabberufeliste.php, cited 20.05.09`

BIBB (2010) Wie viele Ausbildungsberufe gibt es in Deutschland? Online. URL `http://www.bibb.de/de/wlk26560.htm, cited 20.05.09`

Bieg D, Mittag W (2009) Die Bedeutung von Unterrichtsmerkmalen und Unterrichtsmotionen für die selbstbestimmte Lernmotivation. *Empirische Pädagogik, Landau* **23 (2)**:S. 117–142.

Bloom B, Engelhart M, Furst E, et al. (1956) *Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain.* New York: David McKay Co Inc.

BMBF (2009) Berufsbildungsbericht 2009: Vorversion. Online: http://www.bmbf.de/pub/bbb_09.pdf [cited 16.04.2009].

BMBF (2010) Recognized Training Occupations. Website. URL `http://www.bmbf.de/en/550.php; Accessed on 4 July 2010`

Bortz J (2005) *Statistik fuer Human und Sozialwissenschaft*. Springer.

Bowden JA (2009) Competency-based education – neither a panacea nor a pariah. Online:. URL `http://crm.hct.ac.ae/events/archive/tend/018bowden.html`

Bräuer M, Steinhaufand E, Wiest M (2007) Umsetzung des Lernfeldkonzeptes im agraren Fachunterricht. *In: B & B Agrar Die Zeitschrift für Bildung und Beratung* **60**:161 – 166.

British-Council (2001) *Global Education and Training Information Service. Bangladesh: Market notes.* Tech. rep.

Brown P, Lauder H (1995) *Post Fordist possibilities: education, training and national development. In: Bash L., Green A. (ed.): Youth, Education and Work*. Kogan Page, London.

BTEB (2009) Diploma in Engineering Curriculum. Online.
URL `http: //www.bteb.gov.bd/ index.php? option = com_content& task = category&sectionid = 7&id=19& Itemid =32, cited 20.05.09`

Bünning F (2008) *Experimentierendes Lernen in der Bau- und Holztechnik - Entwicklung eines fachdidaktisch begründeten Experimentalkonzepts als Grundlage für die Realisierung eines handlungsorientierten Unterrichts für die Berufsfelder der Bau- und Holztechnik*. Ph.D. thesis, Habilitationsschrift der Otto-von-Guericke-Universität Magdeburg.

Bünning F, Hortsch H, Novy K (2000) *Das britische Modell der National Vocational Qualifications (NVQs): Ausgangspunkt für eine Modularisierung beruflicher Bildung in Deutschland?*, vol. 8 of *Schriftenreihe Studien zur Erwachsenenbildung*. Kovac, Hamburg.

CIA (2010) The world factbook. https://www.cia.gov/library/publications/the-world-factbook/geos/bg.html.

CIPD (2010) Competency and Competency Frameworks. Website.
URL `http://www.cipd.co.uk/subjects/perfmangmt/competnces/comptfrmwk.htm`

Clement U (2003) *Competency-Based Education and Training – Eine Alternative zum Ausbildungsberuf?. In: R. ARNOLD (Hrsg.): Berufsbildung ohne Beruf?* Baltmannsweiler.

Cohen J (1988) *Statistical power analysis for the behavioral sciences*. Hillsdale, New York, Erlbaum.

DACUM (1995) *Introduction to DACUM*. Tech. rep.

Dave R (1975) *Developing and Writing Behavioural Objectives. R J Armstrong (ed.),*. Educational Innovators Press.

Diehl JM, Staufenbiel T (2001) *Statistik mit SPSS Version 10.0*. Eschborn: Klotz.

Ditton H (2002) Unterrichtsqualität - Konzeptionen, methodische Überlegungen und Perspektiven. *Unterrichtswissenschaft* **30 Jg.,**(H. 3):S. 197–212.

Döring R (2003) *Handlungsorientierter Unterricht: Ansätze, Kritik und Neuorientierung aus bildungstheoretischer, curricularer und instruktionspsychologischer Perspektive*. Stuttgart und Berlin: WiKu-Verlag.

DQR (2009) *Discussion proposal for a German Qualifications Framework for Lifelong Learning*. Tech. rep., Prepared by the German Qualifications Framework Working Group.

DTE (2010) Directorate of Technical Education Bangladesh. Online.
URL `http://www.techedu.gov.bd/aboutus.html`

Dunbar K (2002) *The Curriculum. In: Arun K. Mishra and John Bartram (ed.): Skills Development through Distance Education*. The Commonwealth of Learning. Vancouver.

Ellström P (1997) The many meanings of occupational competence and qualification. *Journal of European Industrial Training MCB University Press [ISSN 0309-0590]* **21**(6):266273.

Ellström PE (1994) *Kompetens, lärande och utbildning i arbetslivet. Problem, begrepp och teoretiska perspektiv (Skills, Learning, and Education in Working Life. Problems, Concepts, and Theoretical Perspectives)*. Publica, Stockholm.

Enkenberg J (1994) *Situated Cognition and cognitive Apprenticeship. New Framework for Education of Professional Skills. In: A. Heikkinen (ed.): Vocational Education and Culture - European Prospects from History and Life-History*. Tampere: Tampereen Yliopisto.

EQF (2010) Lifelong Learning Policy. Online. Accessed: 8 May 2010.
URL `http://ec.europa.eu/education/lifelong-learning-policy/doc44_en.htm`

Finch CR, Crunkilton JR (1999) *Curriculum development in vocational and technical education: Planning, content, and implementation*. 5th ed. edn., Allyn and Bacon, Boston.

Fortmüller R (1996) *Wissenschaftsorientierung und Praxisbezug als komplementäre Prinzipien lernpsychologisch fundierter Lehr-Lern-Arrangements. In: Fortmüller, Richard and Aff, Josef (Hrsg.): Wissenschaftsorientierung und Praxisbezug in der Didaktik der Ökonomie. Festschrift Wilfried Schneider. S. 372-400*. Wien: Manz-Verlag Schulbuch.

Fortmüller R, Silberbauer T (2004) Vorwissen und Wissenserwerb. Eine Untersuchung zur Bedeutung der Vorkenntnisse für die Informationsbeschaffung aus dem Internet. *ZBW* **100. Bd.**(1):83–101.

Frackmann M (2001) *Neue Qualifikationsanforderungen und Berufsbildung. In: Bonz, Bernhard (Hrsg.)*.

Franke G (2005) *Facetten der Kompetenzentwicklung. In: Schriftenreihe des Bundesinstituts für Berufsbildung*. Bundesinstitut für Berufsbildung., Bielefeld.

Fraser BJ, Walberg HJ, Welch WW, Hattie JA (1987) Syntheses of Educational Productivity Research. *Journal of Educational Research* **Vol. 11**:p. 145 – 252.

Fretwell DH, Lewis MV, Deij A (2001) *A Framework for Defining and Assessing Occupational and Training Standards in Developing Countries*. Tech. Rep. Information series No. 386.

Gal-Einai (2010) A kabbalistic approach to spiritual growth, kabbalah and education. Online: http://www.inner.org/education/educ48.htm, accessed on 11 May 2010.
URL `http://www.inner.org/education/educ48.htm`

Geißel B (2008) *Ein Kompetenzmodell für die elektrotechnische Grundbildung: Kriteriumsorientierte Interpretation von Leistungsdaten. In: Nickolaus, R. and Schanz, H. (Hrsg.): Didaktik gewerblich-technischer Berufsbildung*. Baltmannsweiler:Hohengehren.

Grüner G (1978) *Bausteine zur Berufsschuldidaktik*. Trier: Spee-Verlag.

Hellwig S (2006) The competency debate in german vet: an analysis of current reform approaches. *International Journal of Training Research* **4**(1):01–16.

Helmke Andreas und Weinert FE (1997) *Bedingungsfaktoren schülicher Leistung. In: Weinert, F. E (Hrsg.): Psychologie des Unterrichts und der Schule*. Verlag für Psychologie (Pädagogische Psychologie), Band 3, S. 71-176.

Hensge K, Goermar G, Lorig B, et al. (2008) *Kompetenzstandards in der Berufsausbildung (Zwischenbericht)*. Tech. rep., Bundesinstitut für Berufsbildung.

Hering D (1998) *Zur Fasslichkeit naturwissenschaftlich und technischer Aussagen. In: Ahlborn H. and Pahl Jörg-Peter (ed.): Didaktische Vereinfachung. Eine kritische Reprise des Wekes von Dietrich Hering*. Kallmeyer'sche Verlagsbuchhandlung GmbH. Seelze-Velber.

Hopkins KD, Stanley JC, Hopkins BR (1990) *Educational and Psychological Measurement and Evaluation*. Allyn & Bacon.

Hossain I (2008) Message of the vice-chancellor. http://www.iutoic-dhaka.edu/.

Humphrey S (1992) *A national skills recognition systemsetting standards and establishing credentials. In: Education in the 1990s: Competencies, Credentialism, Competitiveness?* Canberra: AGPS.

Husen T, Postlethwait T (1985) *The International Encyclopedia of Education*, vol. Vol. 6. Oxford: Pergamon.

ILO-Dhaka (2009) *Draft Bangladesh Skills Development Policy 2010 – 1015*. Tech. rep.

ISCED (1997) International Standard Classification of Education (ISCED 97) Summary. Schweizerische Eidgenossenschaft. Eidgenössisches Departement des Innern EDI, Bundesamt für Statistik BFS. http://www.portal-stat.admin.ch/isced97/files/do-d-15.02-isced-01.pdf.

Jessup G (1989.) *The emerging model of vocational education and training. In: J. Burke (ed.): Competency-based Education and Training*. London: TheFalmer Press.

Johnston HN (1992) *The universities and competency-based standards. In: D.Anderson (ed.): Higher Education and the Competency Movement*. Canberra: Centre for Continuing Education at the Australian National University.

Jucius MJ, Irwin RD (1979) *Personnel Management*. Homewood, Illinois.

Keppel G, Wickens TD (2004) *Design and analysis: A researcher's handbook (4th ed.)*. Upper Saddle River, NJ: Pearson PrenticeHall.

Kerka S (1998) Competency-based education and training: Myths and realities. .

Khanam D, Shamsuddoha M (2003) Development of human resources in bangladesh: An analysis of institutional supports. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1295429.

KMK (1991) Rahmenvereinbarung über die Berufsschule. Bonn: Kultusministerkonferenz. Online. Url = http://www.kmk.org/fileadmin/ veroeffentlichungen_beschluesse/1991/1991_03_15-Rahmenvereinbarung-Berufsschule.pdf.

KMK (2007) *Handreichung für die Erarbeitung von Rahmenlehrplänen der Kultusministerkonferenz für den berufsbezogenen Unterricht in der Berufsschule und ihre Abstimmung mit Ausbildungsordnungen des Bundes für anerkannte Ausbildungsberufe*. Tech. rep., Bonn. Herausgeber: Sekretariat der Kultusministerkonferenz.

KMK (2008) *Verordnung über die Berufsausbildung zum Elektroniker/zur Elektronikerin vom 25. Juli 2008 (BGBl. I S. 1413 vom 30. Juli 2008) nebst Rahmenlehrplan (Beschluss der Kultusministerkonferenz vom 16. Mai 2003)*. Tech. rep.

Knöll B (2007) *Differenzielle Effekte von methodischen Entscheidungen und Organisationsformen beruflicher Grundbildung auf die Kompetenz- und Motivationsentwicklung in der gewerblich-technischen Erstausbildung. In: Karl-Heinz Sommer- Band 1 (1984) bis Band 24 (2002) Reinhold Nickolaus - ab Band 25 (2004) (Hrsg.): Stuttgarter Beiträge zur Berufs- und Wirtschaftspädagogik. Band 30*. Shaker Verlag, Aachen.

Krathwohl DR, Bloom BS, Masia BB (1973) *Taxonomy of Educational Objectives, the Classification of Educational Goals. Handbook II: Affective Domain*. New York: David McKay Co., Inc.

Lienert GA, Raatz U (1994) *Testaufbau und Testanalyse. 5. neubearb. u. erw. Aufl*. Weinheim: Beltz.

Malek R (1998) *Modularisierung. In: J. -P. Pahl and E. Uhe (Hrsg.): Begriffe von A – Z für Praxis und Theorie in Betrieb und Schule*. Seelze: Kallmeyer.

Marzano RJ, Kendall JS (2007) *The new taxonomy of educational objectives*. 2nd ed. edn., Corwin Press, Thousand Oaks CA.

Marzano RJ, Kendall JS (2008) *Designing & assessing educational objectives: Applying the new taxonomy*. Corwin Press, Thousand Oaks.

Mauchly JW (1940) Significance Test for Sphericity of a Normal n-Variate Distribution. *The Annals of Mathematical Statistics* **11**(2):204209.
URL http://projecteuclid.org/DPubS?service=UI &version= 1.0 &verb=Display&handle=euclid.aoms/1177731915

McElvany N (2007) *Förderung von Lesekompetenz im Kontext der Familie*. Waxmann, Münster.

Ministry E (2009) *National Education Policy 2009 (final draft)*. Tech. rep., Education Ministry, Government of Bangladesh.

MinistryOfEducation (2004) *Development of Education - National Report of Bangladesh*. Tech. rep.

Moore I (2009) *The National Technical and Vocational Qualification Framework (TVQF) Concept Paper for Bangladesh*. Tech. Rep. 1.

Nickolaus R (2006) *Didaktik - Modelle und Konzepte beruflicher Bildung: Orientierungsleistungen für die Praxis*, vol. 3 of *Studientexte Basiscurriculum Berufs- und Wirtschaftspädagogik*. Schneider-Verlag Hohengehren, Baltmannsweiler.

Nickolaus R (2008) *Didaktk – Modelle und Konzepte beruflicher Bildung*, vol. Band 3. Scheider Verlag Hohengehren, Baltmannsweiler.

Nickolaus R (2010) Einfluss der betrieblichen Ausbildungsqualität auf die Fachkompetenz in ausgewählten Berufen. *(Antragsskizze)* .

Nickolaus R (2010a) Einflüsse der Methodenwahl auf die Kompetenz- und Motivationsentwicklung - eine Übersicht zu Ergebnissen empirischer Utersuchungen. *Lernen & Lehren Elektrotechnik, Informatik- und Metalltechnik* pp. 73 – 76.

Nickolaus R, Bickmann J (2002) Kompetenz- und Motivationsentwicklung durch Unterrichtskonzeptionen. *In: Die Berufsbildende Schule* **54.**(7-8):S. 236–243.

Nickolaus R, Heinzmann H, Knöll B (2005) Ergebnisse empirischer Untersuchungen zu Effekten methodischer Grundentscheidungen auf die Kompetenz- und Motivationsentwicklung in gewerblich-technischen Berufsschulen. *Zeitschrift für Berufs- und Wirtschaftspä-dagogik Stuttgart: Franz Steiner Verlag* **101. Band**(H. 1.):58–78.

Nickolaus R, Knöll B, Gschwendtner T (2006) Methodische Präferenzen und ihre Effekte auf die Kompetenz- und Motivationsentwicklung – Ergebnisse aus Studien in anforderungsdifferenten Ausbildungsberufen in der Grundbildung. *Zeitschrift für Berufs- und Wirtschaftspädagogik, Stuttgart: Franz Steiner Verlag* **Bd. 101**(H. 4.):S. 552–577.

Nölker H (1985) *Glossar Internationale Berufspädagogik: [deutsch english français español]*. Beruf und Bildung, Expert-Verlag, Sindelfingen.

OXFORD-Dictionary (1989) Oxford advanced learners dictionary (oald).

Oxtoby R (1997) Barriers to the Provision of Cost-effective Technical Education in Bangladesh. *Int Journal of Educational Development* **Vol 17. No 1**:91–99.

Pekrun R, Schiefele U (1996) *Emotions- und motivationspsychologische Bedingungen der Lernleistung. In: Enzyklopädie der Psychologie: Themenbereich D Praxisgebiete*, vol. Band 2 Psychologie des Lernens und der Instruktion. of *Serie Pädagogische Psychologie*. Weinert, Franz E., Göttingen: Hogrefe.

Pfeffer J (1995) *Competitive Advantage Through People*. Harvard Business School Press, Boston, MA.

Pierce C, Block R, Aguinis H (2004) Cautionary note on reporting eta-squared values from multifactor anova designs. *Educational and Psychological Measurement* **64(6)**:916924.

Raddatz R, Schröter HG (1999) *Fachglossar: Deutsche Berufsbildungsbegriffe =: Terms of German vocational education = Termes de la formation professionelle allemande = Terminologia en la formación profesional Alemana = Nemeckie ponjatija po professional'nomc obraçeovaniju*. Wirtschafts- und Beschäftigungsförderung Arbeitsfeld Berufliche Bildung, 1. aufl. edn., Bertelsmann, Bielefeld.

Rauner F (1986) *Elektrotechnik Grundbildung. ´Uberlegungen zur Techniklehre im Schwerpunk Elektrotechnik der Kollegschule*. Soester Verlagsgesellschaft, Soest.

Ray S, Sinha AK, Chaudhuri S (2007) *Making Bangladesh a Leading Manpower Exporter: Chasing a Dream of US$ 30 Billion Annual Migrant Remittance by 2015*. Tech. rep.

Reetz L (1990) *Zur Bedeutung der Schlüsselqualifikationen in der Berufsbildung. In: Reetz, L. and Raitmann, T. (Hrsg.): Schlüsselqualifikationen. Dokumentation des Symposiums in Hamburg. " Schlüsselqualifikationen – Fachwissen in der Krise"*. Hamburg: Feldhaus.

ReferNet-Germany (2009) Germany. VET in Europe Country Report 2009. European Centre for the Development of Vocational Training (Cedefop). Online. URL `http://libserver.cedefop.europa.eu/vetelib/eu/pub/cedefop/vetreport/2009_CR_DE.pdf`

Reinberg A (1999) Der qualifikatorische Strukturwandel auf dem deutschen Arbeitsmarkt Entwicklungen, Perspektiven und Bestimmungsgründe. *Mitteilungen aus der Arbeitsmarkt- und Berufsforschung* **32. Jg**(4):434–443.

Reuling J (1996) Modularisierung in der englischen Berufsbildung. *Berufsbildung in Wissenschaft und Praxis 25* **2**.

Ritzen JMM, Balderston JB (1975) *Methodology for planning technical education: With a case study of polytechnics in Bangladesh*. Praeger special studies in international economics and development, Praeger, New York.

Rubenson K, Schütze H (1993) *Learning at and through the workplace: a review of participation and adult learning theory*. OECD,What Makes Workers Learn?, Hampton Press, Cresskill, NJ.

Scheiter K (2004) *Sequenz- und Sequenzierungseffekte bei der Bearbeitung voraussetzungsreicher Aufgaben*. Ph.D. thesis, Universität Tübingen.

Schiefele U, Krapp A, Schreyer I (1993) Metaanalyse des Zusammenhangs von Interesse und schulischer Leistung. *Zeitschrift für Entwicklungspsychologie und Pädagogische Psychologie* **25 Jg.**(H. 2):120 – 148.

Simpson EJ (1972) *The Classification of Educational Objectives in the Psychomotor Domain*. Washington, DC: Gryphon House.

Spady WG (1977) Competency-based education: a bandwagon in search of a definition. *Educational Researcher* pp. p 6(1), 9–14.

Stammen RM (1997) Web Pages Created Via SCID Process.

Student WSG (1908) The probable error of a mean. *Biometrika* **6**(1):125.

Tippelt R, Amorós A (2003) *Competency-based training - Compilation of seminar subject matter: Training the trainers. In: InWEnt: Beiträge aus der Praxis der beruflichen Bildung*. InWEnt Capacity Building International, Germany.

Tuxworth E (1989) *Competency-based education and training: background and origins. In: J. W. Burke (ed.): Competency-based Education and Training*. London: The Falmer Press.

UNDP (2009) *Human Development Report 2009 - Bangladesh*. Tech. rep., UNDP.

UNEVOC (2010) TVET Curriculum Development and Basic Skills. Accessed on 11 Mai 2010. URL `http://www.unevoc.unesco.org/2.0.html?&no_cache=1&tx_drwiki_pi1[keyword]=TVET%20Curricula`

UNFPA (2007) *Reproductive Health and Rights is Fundamental for Sound Economic Development and Poverty Alleviation,*. Tech. rep., UNFPA.

US_Departmet (2010) *Background Note: Bangladesh*. Tech. rep., U.S. Department of State. URL `http://www.state.gov/r/pa/ei/bgn/3452.htm`

Vargas-Zuniga F (2005) *Key Competencies and Employability. In: The new ILO Recommendation 195 – Human resources development: education, training and lifelong learning*. ILO. ISBN 9290881860.

VET-LSA (2009) VET-LSA: General concept (Version 28.07.2009), International Large-Scale Assessment for Vocational Education and Training (VET-LSA). Online. Accessed on 23 May 2010.
URL `http://www.bmbf.de/pub/VET-LSA_General_Concept_version_280709.pdf`

Wang MC, Haertel GD, Walberg HJ (1993) Toward a knowledge base for school learning. *Review of Educational Research* **Vol. 63, H. 3,**:S. 249 – 294.

Weinert FE (1996) *Lerntheorien und Instruktionsmodelle. In: Franz E. Weinert (Hrsg.): Psychologie des Lernens und der Instruktion. Pädagogische Psychologie*, vol. Bd. 2 of *Praxisgebiete: Ser. 1, Pädagogische Psychologie*. Göttingen u.a: Hogrefe (Enzyklopädie der Psychologie: Themenbereich D.

White RV (1988) *The ELT curriculum: Design, innovation and management.* Oxford: Basil Blackwell.

Wilson LO (1990) Curriculum course packets ed 721 & 726. Unpublished.

Wilson LO (2006) Beyond Bloom - A new Version of the Cognitive Taxonomy. Online.
URL `http://www.uwsp.edu/education/lwilson/curric/newtaxonomy.htm`

Winther E, Achtenhagen F (2009) Measurement of Vocational Competencies – a contribution to an international large-scale assessment on vocational education and training. *Empirical Research in Vocational Education and Training* **1**(1):85 –108.

Xaymountry B (2009) *Die Implementierung von Competency-Based-Training-Ansätzen in Südostasien*. Ph.D. thesis, Technische Universität Dresden.

A. The Test Instrument

A.1. The Test Instrument

Universität Stuttgart
Institut for Educational Science
and Psychology
Department of Vocational Education

BWT
Abteilung Berufs-,
Wirtschafts- und
Technikpädagogik

Technical Competency Test

For the survey of occupational expertise at the end of

4-Year Diploma in Engineering (Electronics Technology) Programme

of Bangladesh Technical Education Board

Time: 60 minutes

To be noted:

- There are16 tasks, 14 pages. All tasks are to be answered.
- In case of "multiple-choice" there can be more than one correct answer. For each false choice there will be a negative (-) mark.
- For computing tasks the used formulas and steps are to be written.
- There will be mark(s) even for a partial answer to a question.

Resources/tools: only calculator (no table books)

Name: ………………………………… Gender ☐ m ☐ f

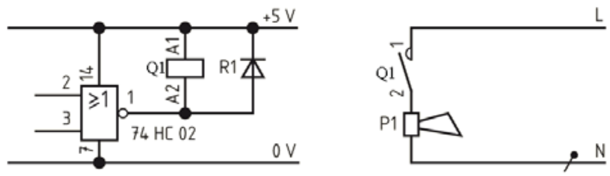
Class: …………………………………

Institute:…………………………………

Task-Group A

Electronics and Relays/Contactors
Task 1
To isolate the main circuit from the control circuit (galvanic isolation) relays and contactors are often used. Figure 1 shows the relay Q1 (relay-coil A1/A2 and relay contact 1/2) and the logic module 74HC02 (a NOR-logic connection). The control circuit should be able to control the horn (P1) on the main circuit.

Q1.1 Complete the following truth table.



Truth Table for 74HC02

Inputs		Outputs
2	3	1
0	0	
0	1	
1	0	
1	1	

Figure 1: Relay circuit with separate control and main circuit

Q1.2 Mark the correct answer(s)
- □ The horn will sound if the output 1 is in the high state (logical 1).
- □ The horn will sound if the output 1 is in the low state (logical 0)..
- □ The horn will sound always independent to the state of output 1, because it is on a separate circuit.
- □ The horn will never sound, because it is on a separate circuit.

Task 2
The motor M1 in Figure 2 is started via the contactor Q1 by pressing the pushbutton S2. After releasing S2 the contactor Q1 should holds itself in its operated state.
The Q1 switches off when S1 is pressed.
F1 and F2 are protective fuses against overload and short-circuit.

Q2 Mark the correct statement(s), when a wire breakage between the terminal 22 of S1 and the terminal 13 of Q1 occurs during the operation of M1.

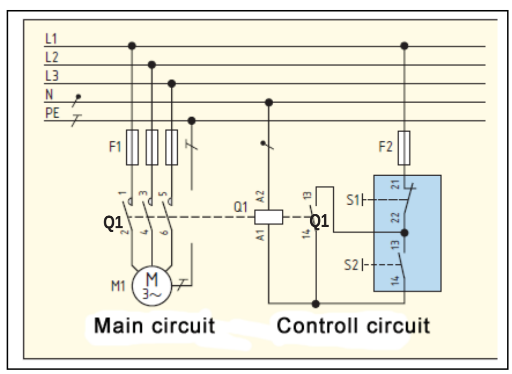
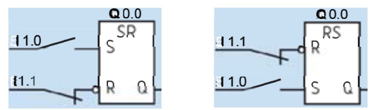


Figure 2: A control circuit with self-holding mechanism for a motor/drive

- □ The wire breakage interrupts the self-holding and the motor stops.
- □ The wire breakage interrupts the self-holding but the motor runs further.
- □ The contactor Q1 can only be operated in inching mode (by pressing S2).
- □ Without repair, the contactor Q1 can not be operated.

Task 3

In case of PLCs we differentiate between two types of memory functions (Figure 3).



(a) Reset dominant (b) Set dominant

Figure 3: Reset priority and set priority memory functions

Q3.1 Assign the following applications to each memory function type in Table 1: *Hazard detection devices, motor/drives, conveyors, and presses/squeezers*.

Table 1

Memory Function Types	Applications
Priority resetting (reset dominant)	
Priority setting (set dominant)	

Q3.2 Following are programme codes using Instruction List (IL), a programming language used for PLC programming according to IEC 1131. Select the correct programme code

i) for the reset dominant flipflop shown in figure 3(a) (A, B, C or D?):

and ii) for the set dominant flipflop shown in figure 3(b) (A, B, C or D?):

(A)	LDN	I1.1	(B)	LD	I1.0	(C)	LDN	I1.1	(D)	LD	I1.0
	R	Q0.0		S	Q0.0		S	Q0.0		R	Q0.0
	LD	I1.0		LDN	I1.1		LD	I1.0		UN	I1.1
	S	Q0.0		R	Q0.0		R	Q0.0		S	Q0.0

Q3.3 The electrical equipment and machines are switched on using 1-signal, ie through a normally open (NO) contact, and switched off using 0-signal, i.e. a normally closed (NC) contact. Give two (safety) reasons for it.

Task 4 Sensors

Sensors convert a non electrical quantity into an electrical quantity. In table 2 are 6 applications for sensors.

Q4.1 From the following sensors: *strain gauge, safety mat, thermistor, optical proximity sensor, inductive proximity sensor* assign at least an appropriate sensor for each application in *Table 2.*

Table 2

Applications	Sensors
Pressure measurement	
Danger-area monitoring	
Torque measurement	
Speed monitoring	
Conveyor belt	
Airconditioner	

Q4.2 Name a rotary position transducer, from which a servo controller can compute: the actual speed/frequency of rotor, the angle/position and the direction of rotation.

Information Technology

Task 5

Figure 4 shows a local area network (LAN) according to fast Ethernet standard. All PC users have the right to access data on the central server and to use the Internet. You are asked to integrate a PC to the network.

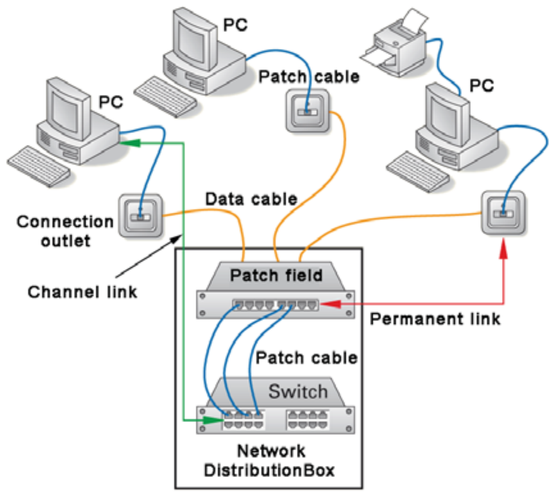


Figure 4: A local area network (LAN).

Q5.1 Complete the following table according to the fast Ethernet standard.

Table

Sl.	Name	Description (speed, category)
1.	Network card	………………… Mbit/s
2.	Patch cable	Cat. ……………or higher
3.	Data cable	Cat. …………….or higher

Q5.2 Give the maximum permissible cable length (channel link):

Q5.3 For a network connection, you must install a network protocol and configure it. Name a network protocol that is commonly used. (Write the short and full name of the protocol)

Q5.4 For your PC you need to choose an IP address. The IP address must be unique in a network. What command will you use at the console level to see the existing network settings?

Task-Group B

Electronics

Task 6.
Figure 5 shows a RS-flipflop.

Q6.1 Which logic state has the output Q for the following input states (Write your answer in the truth table):
i) if the two inputs are at logic 0 (E1 = E2 = 0)
and ii) if the two inputs are at logic 1 (E1 = E2 = 1)?

Q6.2 Complete the truth table.

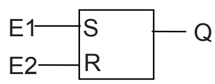


Figure 5: RS-Flipflop

Truth Table

Inputs		Outputs
E1	E2	Q
0	0	
1	1	
0	1	
1	0	

Task 7
Figure 6 shows a Wheatstone bridge circuit with an operational amplifier (OpAmp). B1 and B2 are resistances of passive sensors, for example strain-gauge sensors. Using the Wheatstone bridge the changes of these resistances are captured as electrical voltage and fed to the operational amplifier.

Q7.1 As what function is the operational amplifier used here? Mark (A), (B), (C) or (D).

(A) Comparator (B) Differentiator
(C) Summing amplifier (D) Differential amplifier

Q7.2 Complete the wiring for the operational amplifier shown below (with necessary electrical components) so that it functions as what you have chosen in Q7.1).

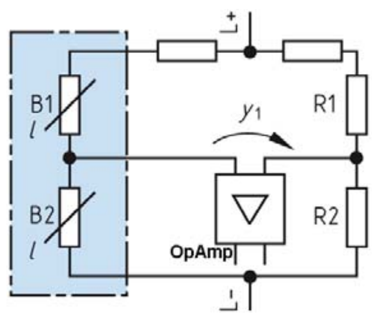
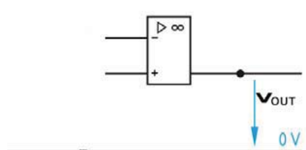


Figure 6: Wheatstone Bridge Circuit



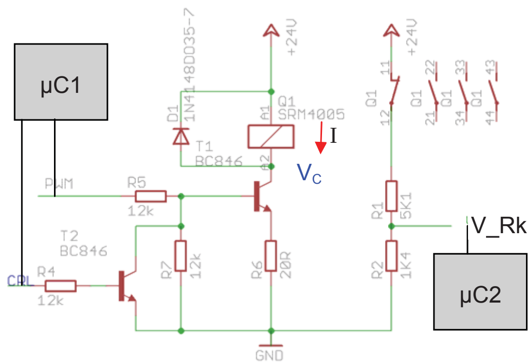
Task 8

A customer requires an electronic device. The device must have safety relay outputs. The schematic in Figure 7 shows a possible implementation of such an output. The forcibly guided relay Q1 (SRM4005) is controlled by the microcontroller µC1 and verified for its correct functionality by the second microcontroller µC2.

Q8.1 Calculate the potential V_Rk with respect to ground GND
i) when the normally closed (NC) contact 11/12 of Q1 is closed

and ii) when normally closed (NC) contact 11/12 of Q1 is open.

Q8.2 Complete the truth table (Use the TTL logic level (0 or 1) for V_Rk).



Truth Table		
Inputs		Output
CRL	PWM	V_Rk
0	0	
0	1	
1	0	
1	1	

Figure 7: Relay Control and Verification

Q8.3 The micro-controller µC1 monitors other safety arrangements, for example a protecting door. Assume that the protecting door is closed, the µC1 writes a logic 0 on the control pin CRL, i.e. CRL = 0. Complete the following timing diagram for the collector potential V_C of the transistor T1 and the relay coil current I_R, when the µC1 applies a periodic pulse width modulated signal on the control pin PWM.

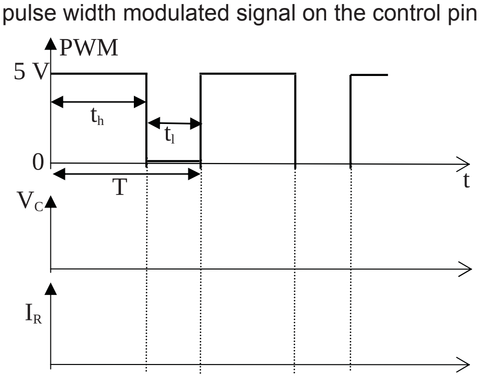


Figure 7-1: Timing diagram for V_C and I_R

Q8.4 Will the relay operate and remain steady or follow the signal PWM (disturbance!)? Justify your answer (hints: the effect of the time duration of t_h and t_l).

Q8.5 Name a bus over which the µC2 can send the status of the relay to the µC1

Q8.6 What function has the diode D1 in this circuit (Figure 7)?

Task 9.

To communicate between a microcontroller and a PC you will need to design a serial interface. Figure 8 shows the datasheet of a RS-232 driver/receiver. It is required for interfacing the serial port of the PC (RS-232 Standard) with the serial port of the microcontroller (TTL/CMOS standard).

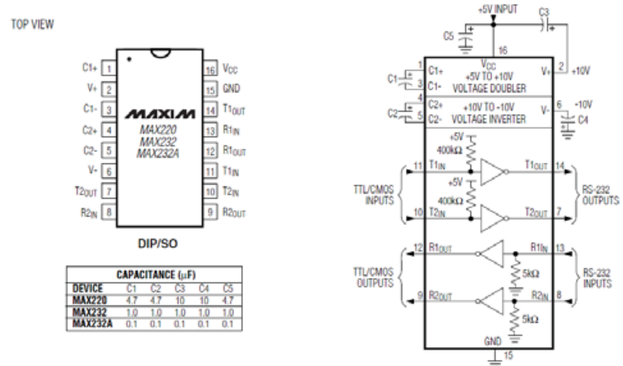


Figure 8: Datasheet of MAX220/MAX232/MAX232A (Pin Configuration and Typical Operating Circuit).

Q9.1 Complete the prepared circuit diagram in Figure 9 that connects the chip MAX232 to the serial port of the microcontroller (RXD, TXD) and to the 9-pin sub-D connector.

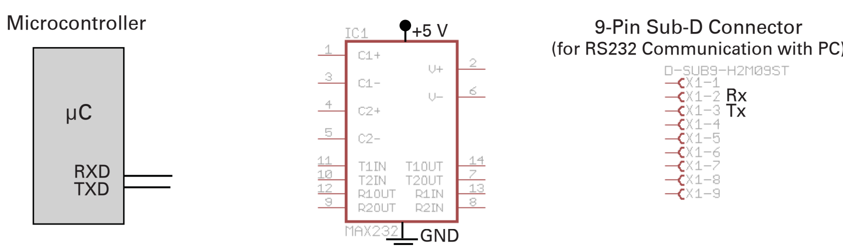


Figure 9: Circuit diagram for serial interface

Q9.2 Wire the chip MAX232 with appropriate value of capacitors required for it. (See also Datasheet in Figure 8)

Programming Language C

Task 10

The following source code implements a logic module in C.

```
typedef struct
{   unsigned    char    Input_Sigs;     /* bit7 bit6 bit5 bit4 bit3 bit2 bit1 bit0 */
    unsigned    char    Output_Sigs;    /* bit7 bit6 bit5 bit4 bit3 bit2 bit1 bit0 */
}LogicModule;

LogicModule    Lm;

if ((Lm.Input_Sigs & 0x0F) == 0x0F )    { Lm.Output_Sigs = Lm.Output_Sigs | 0x10;}
else    {Lm.Output_Sigs = Lm.Output_Sigs & 0xEF;}
```

Q10.1 Name the basic logic function (OR, AND, or EXOR) programmed above.

Q10.2 Write which bit(s) of *Input_Sigs* and *Output_Sigs* are used for this logic module.

Task-Group *C*

Industrial Communication

Task 11 Compared to conventional cabling significant cost savings and functional benefits can be achieved through the use of industrial networks. The selection of the preferred network type usually depends on the control systems used in plants, manufacturers, the functional requirements in terms of speed and network expansion as well as the availability of suitable field devices. In Table 3 are some of such industrial networks, interfaces or buses.

Q11.1 Write the full names of the following abbreviations in Table 3:
CAN, ASI and PROFIBUS DP

Q11.2 Below are some application areas of industrial buses:
building automation, industry automation, automotive, and process automation.
Assign at least an application area from the above list to the appropriate network/interface/bus in Table 3.

Table 3

Abbreviations	Full Names	Application areas
EIB, for example	European Installation Bus	building automation
CAN		
ASI		
PROFIBUS DP		

Uninterruptible Power Supply (UPS)

Task 12
To secure the important data against power failure, UPSs are used. You have received an order to install an appropriate UPS. For future expansions, a power reserve of 25% of the new UPS should be scheduled. In server room are the following devices:

Server-PC → 500W
Monitor 17", Rating → V = 230V, I = 0.75 A, cos φ = 0.8
Laser printer → 25 W standby/ 560 W in-operation
Switch → 20 W
DSL-router → 5 W

Q12.1 Which devices must remain operative, if a "failure notice" as e-mail is to be sent at power failure?

Q12.2 Calculate the required power of the USP with a reserve of 25% of the new UPS.

Electrical Motors/Drives

Task 13

To drive a mobile robot DC motors with built-in gears are used. The motor data are N = 100 rpm at a voltage of V =+12 V.

Q13.1 The motors are operated from a battery voltage of Vb = +9 V.
Calculate the speed of the motors when operating with the battery.

Q13.2 The speed of the motors is controlled using a pulse width modulated (PWM) signal. The motors are supplied by a voltage shown in figure 10. The frequency of the signal is f = 100 Hz. The motors should run with a speed of N = 10 rpm. Determine the pulse duration t_i of V_{PWM}.

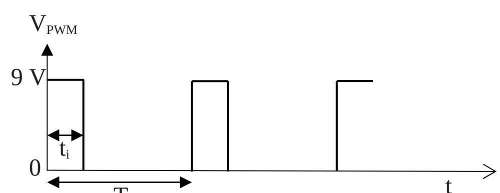


Figure 10: Periodic pulse with modulated control voltage

Machine Safety

Task 14

If the constructive actions of the machine are not sufficient to minimise the risk of injury additional safety measures must be included. Figure 11 shows a combination of a PLC and a safety device with Emergency STOP switching.

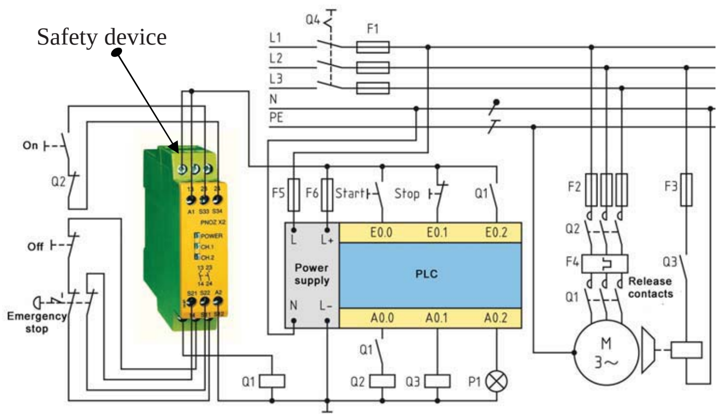


Figure 11: PLC with Emergency STOP safety device.

Q14.1 Mark the correct statement(s) about the Emergency STOP switch:

- ☐ The knob must be red and the background yellow.
- ☐ The knob must be red and the background black.
- ☐ It must have self-locking and forcibly opening contacts.
- ☐ For Emergency STOP are also footswitches without mechanical protection approved.

Q14.2 You have started the motor (in Figure 11) properly and then pressed the Emergency STOP button. What will happen? (Mark the correct statement(s):

- ☐ The safety device will be cut-off from the power supply. The motor will be running.
- ☐ The entire installation will be cut off from the main supply.
- ☐ The energy intakes to the motor (the potentially hazardous part of the installation) will be cut off soon.
- ☐ By pressing the `Start´ button the motor can be restarted. A setback of the Emergency STOP switch is not necessarily needed before.
- ☐ The re-start of the motor after an emergency stop is done by a start function and is only possible when the Emergency STOP switch was setback by hand previously.

Task 15
In Appendix 1, page 13, is a device for Emergency STOP and for protecting door (safety gate) applications.

Q15.1 Complete the connection diagram in Figure 12, where you are to wire (connect) the device ESR4-NO-30 for Emergency STOP button as **"two-channel, manual start with cross monitoring"** (see Appendix 1, page 13). (Note A1 = + L and A2 = 0V (GND).)

Q15.2 Draw also the necessary switches and/or buttons. Also connect the PLC input I0.2 with 24 V through one of the safety contacts of ESR-NO-30, for example contact 13/14, so that the output Q0.2 of the PLC can be switched off accordingly.

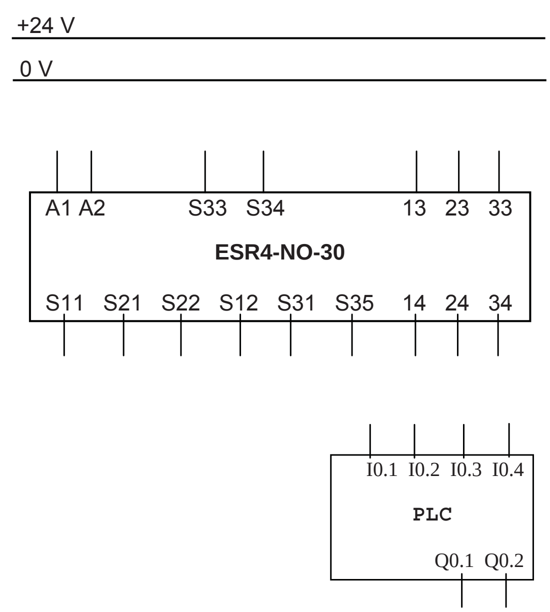
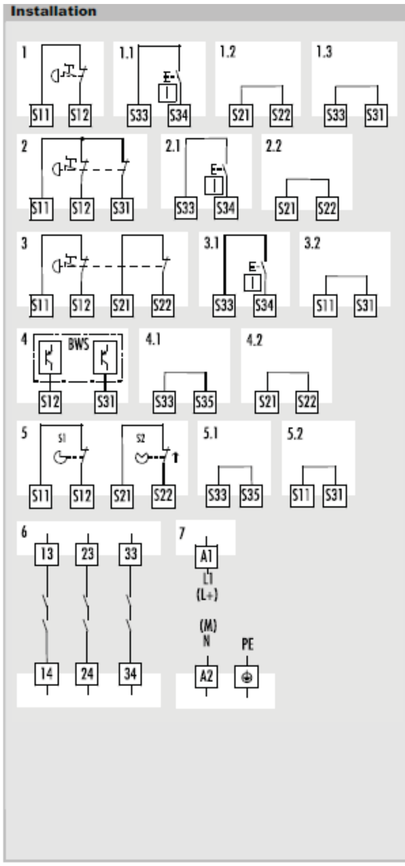


Figure 12: Connection diagram.

Appendix 1: Instructions for using the device ESR4-NO-30 for Emergency STOP
Basic unit for emergency STOP and safety gate applications

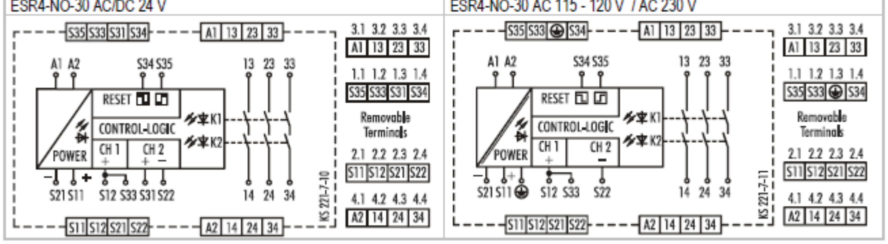
Installation



	Beachten Sie bei der Installation das Anschlussschaltbild.	Please consult the connection diagram during installation.	Lors de l'installation, respecter le schéma des connexions.
1	**Not-Aus-Taster** einkanalig, manueller Start (für DC-Geräte)	**Emergency stop button** single-channel, manual start (for DC devices)	**Arrêt d'urgence** monocanal avec démarrage manuel (pour appareils DC)
1.1	Reset-Taster	Reset button	Bouton-poussoir Reset
1.2	Brücke	Bridge	Pont
1.3	Brücke	Bridge	Pont
2	**Not-Aus-Taster** zweikanalig, manueller Start, ohne Querschlusserkennung (für DC-Geräte)	**Emergency stop button** two-channel, manual start, without cross monitoring (for DC devices)	**Arrêt d'urgence** à deux canaux, avec démarrage manuel sans détection de courts-circuits (pour appareils DC)
2.1	Reset-Taster	Reset button	Bouton-poussoir Reset
2.2	Brücke	Bridge	Pont
3	**Not-Aus-Taster** zweikanalig, manueller Start, mit Querschlusserkennung	**Emergency stop button** two-channel, manual start, with cross monitoring	**Arrêt d'urgence** à deux canaux, avec démarrage manuel, avec détection de courts-circuits
3.1	Reset-Taster	Reset button	Bouton-poussoir Reset
3.2	Brücke (für DC-Geräte)	Bridge (for DC devices)	Pont (pour appareils DC)
4	**OSSD-Ansteuerung** zweikanalig, automatischer Start, ohne Querschlusserkennung (für DC-Geräte)	**OSSD actuation** two-channel, automatic start, without cross monitoring (for DC devices)	**OSSD** à deux canaux, avec démarrage automatique sans détection de courts-circuits (pour appareils DC)
4.1	Brücke	Bridge	Pont
4.2	Brücke	Bridge	Pont
5	**Schutztür** zweikanalig, automatischer Start, mit Querschlusserkennung	**Safety gate** two-channel, automatic start, with cross monitoring	**Porte de protection** à deux canaux, avec démarrage automatique, avec détection de courts-circuits
5.1	Brücke	Bridge	Pont
5.2	Brücke (für DC-Geräte)	Bridge (for DC devices)	Pont (pour appareils DC)
6	**Freigabestrompfade** 3 Schließer, zwangsgeführt	**Enabling current paths** 3 NO contacts, positively driven	**Contacts de sortie** 3 contacts de travail, à guidage forcé
7	**Versorgungsspannung** (PE nur bei AC-Geräten)	**Supply voltage** (PE on AC devices only)	**Tension d'alimentation** (PE uniquement pour les appareils AC)

Anschlussschaltbilder / Connection Diagrams / Schémas de connexions

ESR4-NO-30 AC/DC 24 V | ESR4-NO-30 AC 115 - 120 V / AC 230 V



Small Controllers/ PLC

Task 16

You have got a contract to develop a control programme for a construction lift (Figure 13). As a controlling device you will be using a small controller (or a PLC). The lift basket should be able to move between the two limit switches S2 at the top and S4 at the bottom automatically. When the 'Stop' button is pressed, the lift should stop immediately. If the `Up'/ `Down' button is pressed, the drive should continue its journey automatically. A three-phase motor (M) is used as drive. The motor is switched on/off via contactors Q1 (Up) and Q2 (Down). A protective interlocking and a locking latch in the programme of the controller must be used to prevent the motor from simultaneous right-left run. When the motor is overloaded the lift must be stopped by the over current relay (F1) immediately.

Q16 Draw the functional block diagram (FBD) or ladder diagram (LD) for this control programme. Use the allocation table and the connection layout (*Figure 14*) of the controller.

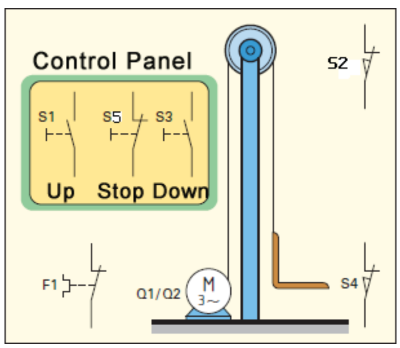


Figure 13: A construction lift and control panel.

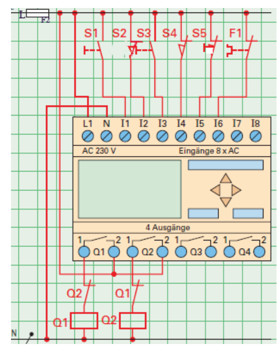


Figure 14: Terminal connection layout.

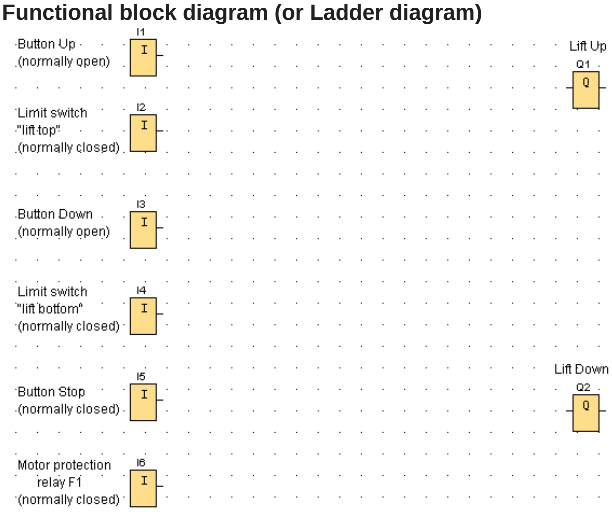
Allocation table

1 → Input and outputs of the controller

2 → Operating resources

1	2	Description
I1	S1	Button lift Up (normally open)
I2	S2	Limit switch lift `top' (normally closed)
I3	S3	Button lift Down (normally open)
I4	S4	Limit switch lift `bottom' (normally closed)
I5	S5	Button lift Stop (normally closed)
I6	F1	Motor protection relay (normally closed)
Q1	Q1	Main contactor, lift Up
Q2	Q2	Main contactor, lift Down

Functional block diagram (or Ladder diagram)



B. Competency Test: Evaluation of Tasks used and Test Results

B.1. The Evaluation of the Tasks

		Task01	Task02	Task03	Task04	Task05	Task06	Task07	Task08
Practical relevance	MV	4.0	4.1	3.4	4.4	3.3	3.7	3.5	4.0
	SD	0.47	0.74	0.84	0.52	1.16	0.48	0.71	0.67
	MD	4.0	4.0	3.0	4.0	3.5	4.0	4.0	4.0
	MO	4.0	4.0	3.0	4.0	4.0	4.0	4.0	4.0
	Mn	3.0	3.0	2.0	4.0	1.0	3.0	2.0	3.0
	Mx	5.0	5.0	5.0	5.0	5.0	4.0	4.0	5.0
Complexity	MV	2.4	2.5	3.0	2.1	2.9	2.0	3.1	3.9
	SD	0.74	0.74	0.76	0.99	1.19	0.76	0.83	0.70
	MD	3.0	3.0	3.0	2.0	3.0	2.0	3.0	4.0
	MO	3.0	3.0	3.0	2.0	2.0	2.0	3.0	4.0
	Mn	1.0	1.0	2.0	1.0	1.0	1.0	2.0	3.0
	Mx	3.0	3.0	4.0	4.0	5.0	3.0	5.0	5.0
Comprehensibility	MV	4.3	4.2	4.0	4.3	4.2	4.6	3.8	3.6
	SD	0.59	0.68	0.76	0.59	0.77	0.51	0.68	0.63
	MD	4.0	4.0	4.0	4.0	4.0	5.0	4.0	4.0
	MO	4.0	4.0	4.0	4.0	4.0	5.0	4.0	3.0
	Mn	3.0	3.0	3.0	3.0	3.0	4.0	3.0	3.0
	Mx	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Probability	MV	3.8	3.5	3.2	37	2.5	4.2	3.1	2.6
	SD	1.08	1.30	1.10	0.60	1.06	0.77	0.83	1.04
	MD	4.0	4.0	3.0	4.0	2.0	4.0	3.0	3.0
	MO	4.0	4.0	3.0	4.0	2.0	4.0	4.0	3.0
	Mn	1.0	1.0	1.0	3.0	1.0	3.0	2.0	1.0
	Mx	5.0	5.0	5.0	5.0	4.0	5.0	4.0	4.0

Table B.1.: Descriptive statistics: The results of the expert/teacher rating (Bangladesh and Germany combined) of Task 1 to 8

		Task09	Task10	Task11	Task012	Task13	Task14	Task15	Task16
Practical relevance	MV	3.3	3.0	3.5	4.1	3.6	3.8	3.7	4.4
	SD	0.95	0.82	0.97	0.74	0.84	0.92	0.67	0.52
	MD	3.0	3.0	3.0	4.0	4.0	4.0	4.0	4.0
	MO	3.0	3.0	3.0	4.0	4.0	4.0	4.0	4.0
	Mn	2.0	2.0	2.0	3.0	2.0	2.0	3.0	4.0
	Mx	5.0	4.0	5.0	5.0	5.0	5.0	5.0	5.0
Complexity	MV	3.4	2.6	2.2	2.3	2.9	3.1	3.5	4.1
	SD	0.99	0.91	1.21	0.75	0.76	0.66	0.64	0.70
	MD	3.0	3.0	2.0	2.0	3.0	3.0	4.0	4.0
	MO	3.0	3.0	1.0	2.0	3.0	3.0	4.0	4.0
	Mn	2.0	1.0	1.0	1.0	2.0	2.0	2.0	3.0
	Mx	5.0	4.0	5.0	3.5	4.0	4.0	4.0	5.0
Comprehensibility	MV	3.9	4.1	4.5	4.5	4.2	3.7	4.0	3.9
	SD	0.74	0.74	0.64	0.64	0.68	0.46	0.76	0.74
	MD	4.0	4.0	5.0	5.0	4.0	4.0	4.0	4.0
	MO	4.0	4.0	5.0	5.0	4.0	4.0	4.0	4.0
	Mn	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	Mx	5.0	5.0	5.0	5.0	5.0	4.0	5.0	5.0
Probability	MV	1.6	1.5	2.5	3.4	3.4	2.6	2.4	2.5
	SD	0.91	0.83	1.46	1.12	0.99	1.24	1.21	1.05
	MD	1.0	1.0	3.0	4.0	3.0	3.0	3.0	3.0
	MO	1.0	1.0	1.0	4.0	3.0	3.0	1.0	3.0
	Mn	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Mx	4.0	4.0	5.0	5.0	5.0	5.0	4.0	5.0

Table B.2.: Descriptive statistics: The results of the expert/teacher (Bangladesh and Germany combined) rating of Task 9 to 16)

B.2. The Competence Test Results

B.2.1. Country performance: task specific statistics

Statistics: Test Results Bangladesh

	N Valid	Mean	Median	Mode	Std. Deviation	Min/Max	Total points (allocated)
Total	160	9.269	9.500	8.0[a]	4.7051	0/21.0	100
Q1	160	1.472	2.000	2.0	1.0892	0/3.0	3.0
Q2	160	.444	.000	.0	.6418	0/2.0	2.0
Q3	160	.488	.000	.0	.8812	0/4.0	8.0
Q4	160	2.975	3.000	4.0	1.7191	0/6.0	8.0
Q5	160	.300	.000	.0	.9404	0/5.5	6.5
Q6	160	1.006	1.000	1.0	.8633	0/3.0	3.0
Q7	160	.400	.000	.0	.8025	0/4.0	6.0
Q8	160	.850	.500	.0	1.0230	0/4.0	15.0
Q9	160	.019	.000	.0	.1763	0/2.0	6.5
Q10	160	.000	.000	.0	.0000	0/0	3.0
Q11	160	.050	.000	.0	.2186	0/1.0	6.0
Q12	160	.572	.000	.0	.7987	0/2.5	4.5
Q13	160	.463	.000	.0	.6624	0/3.0	6.0
Q14	160	.231	.000	.0	.5605	0/3.0	3.5
Q15	160	.000	.000	.0	.0000	0/0	5.0
Q16	160	.000	.000	.0	.0000	0/0	14.0

a. Multiple modes exist. The smallest value is shown

Statistics: Test Results Germany

	N Valid	Mean	Median	Mode	Std. Deviation	Min/Max	Total points (allocated)
Total	160	36.419	35.750	30.0[a]	10.4015	10.5/68.0	100
Q1	160	1.641	2.000	3.0	1.1440	.0/3.0	3.0
Q2	160	.956	1.000	.0	.8997	.0/2.0	2.0
Q3	160	3.944	3.500	3.0[a]	2.3432	.0/8.0	8.0
Q4	160	4.163	4.000	5.0	1.3868	.0/7.0	8.0
Q5	160	1.709	1.000	.0	1.8210	.0/6.5	6.5
Q6	160	1.075	1.000	1.0	.5326	.0/3.0	3.0
Q7	160	1.847	2.000	2.0	1.6048	.0/6.0	6.0
Q8	160	4.247	3.500	3.0	3.0802	.0/14.0	15.0
Q9	160	1.375	1.000	.0	1.5591	.0/6.5	6.5
Q10	160	.256	.000	.0	.6635	.0/2.0	3.0
Q11	160	1.263	1.000	.0	1.3186	.0/6.0	6.0
Q12	160	2.481	2.500	2.5	.9314	.0/3.5	4.5
Q13	160	1.950	2.000	2.0	1.3943	.0/6.0	6.0
Q14	160	2.188	2.500	3.0	1.0090	.0/3.5	3.5
Q15	160	2.147	2.000	.0	1.7587	.0/5.0	5.0
Q16	160	5.178	6.000	.0	3.7732	.0/14.0	14.0

a. Multiple modes exist. The smallest value is shown

B.2.2. Vocational school/class performance in Germany: task-group specific

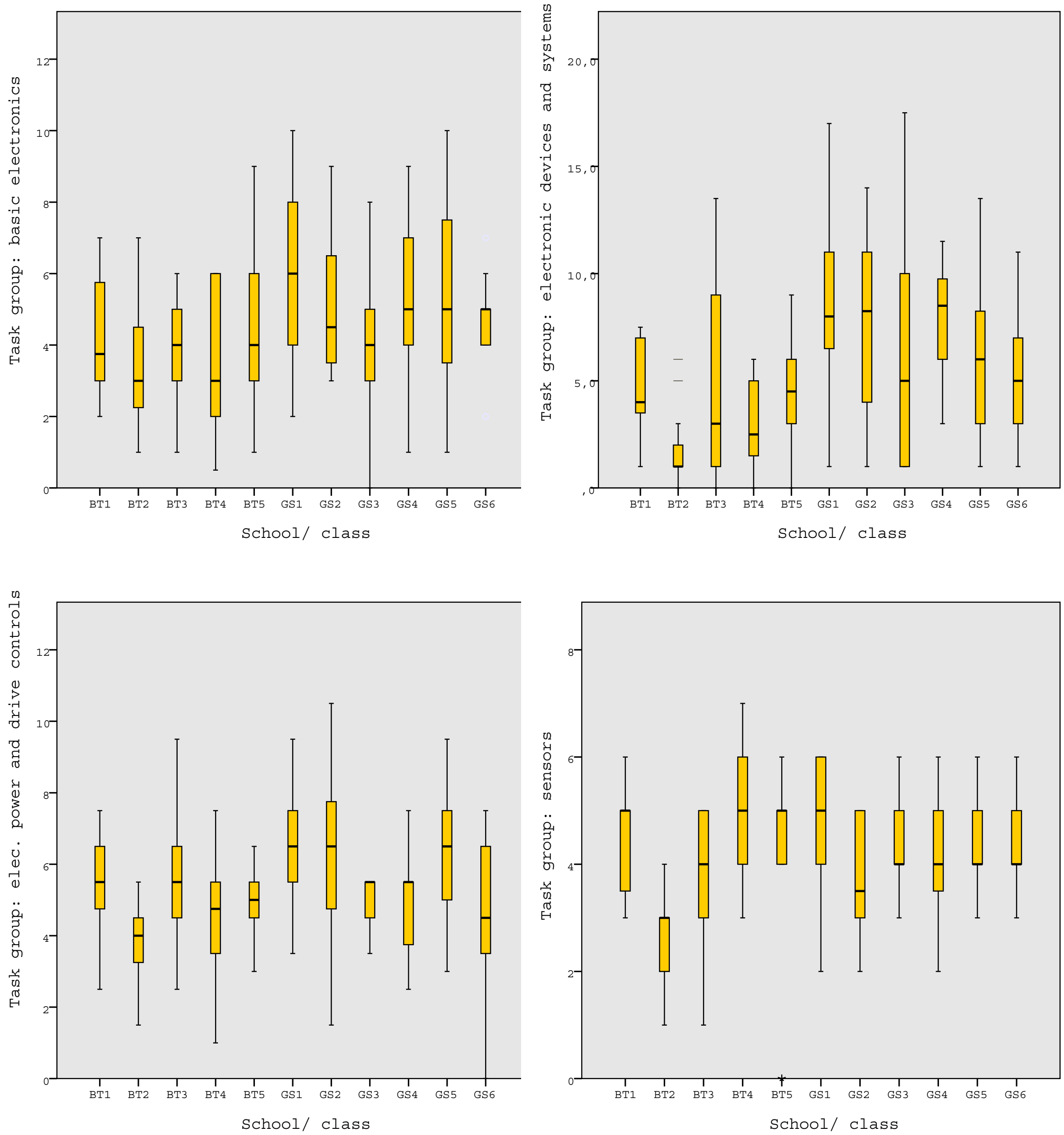


Figure B.1.: Task-group specific school/class performances. (BT = Electronics Technicians (Industrial Engineering), GS = Electronics Technicians (Devices and Systems))

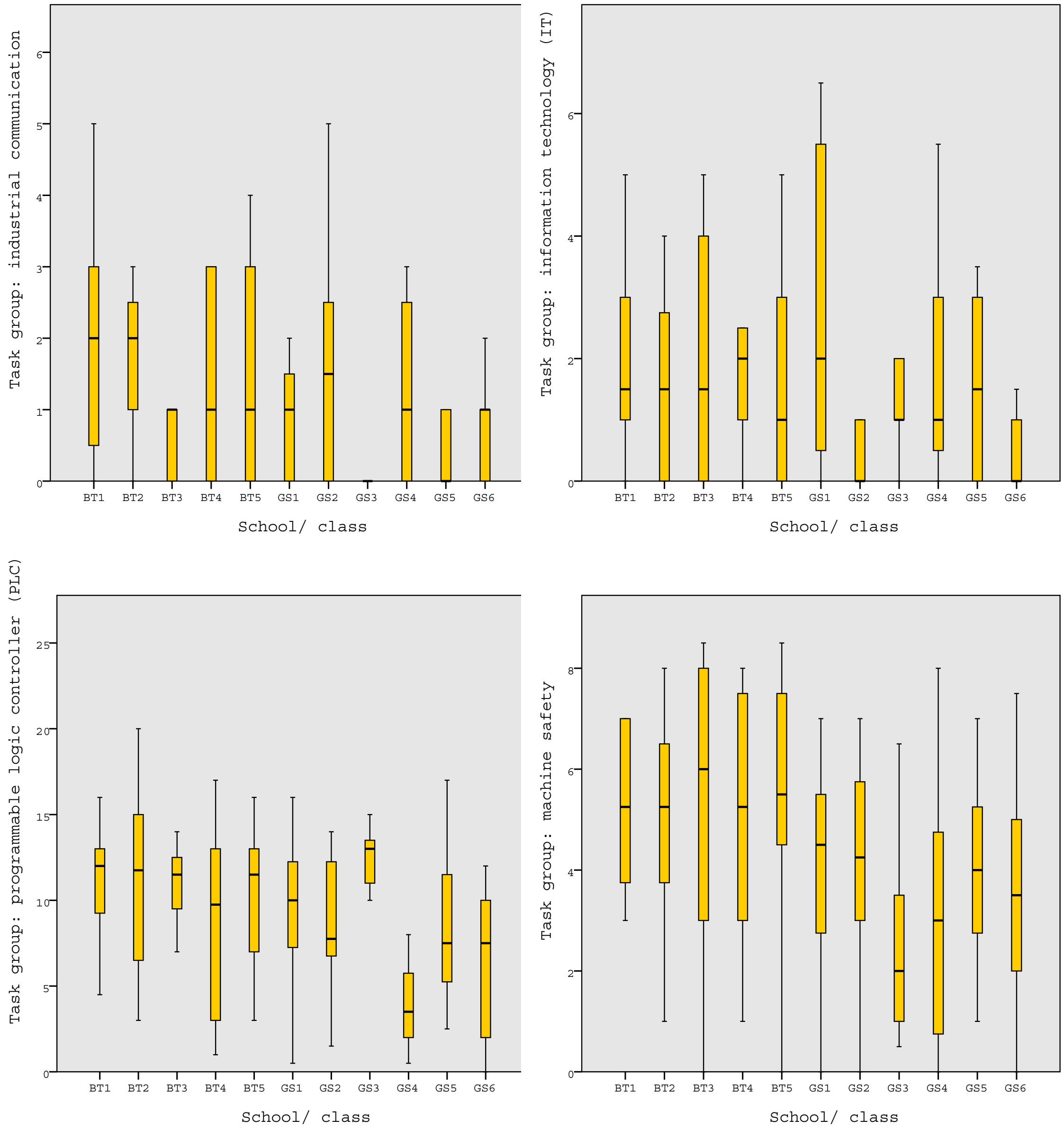


Figure B.2.: Task-group specific school/class performances. (BT = Electronics Technicians (Industrial Engineering), GS = Electronics Technicians (Devices and Systems))

C. Methodologies for Development of Occupational Standards

Three methodologies for defining occupational standards reflect the evolution from initial task-based to competence-based occupational analysis and standards. The methods include job / task analysis, DACUM, and Functional Analysis (Fretwell et al., 2001).

C.1. Job/Task Analysis

The establishment of occupational skill standards started with job analysis. Frederick Taylor (1911), the originator of scientific management, is usually credited with conducting the first formal job analyses. This approach has been predominant for a long time in many industrialized countries, since it is especially suited to analyze tasks in a mass production process and in situations where there is little flexibility in the organization of production processes. The aim of the analysis is to divide and subdivide jobs and tasks into their constituent parts, in order to provide information for training and to develop benchmarks for piece rate wages. In spite of fundamental changes in job and task analysis, the approach is still used for specific purposes and in certain sectors, including some service and administrative occupations.

C.2. DACUM

The DACUM approach to occupational analysis is quite different from job analysis (Norton 1997). DACUM is an acronym for Developing A CurriculUM, but it actually involves only the first step in a full vocational curriculum development process. Instead of job observation, DACUM uses guided group discussion with expert workers. The DACUM process includes, in addition to occupational specific tasks, the separate identification of work enablers: general knowledge and skills, worker behaviors (personal traits and interpersonal skills), and tools and equipment used. These tasks become the focus of curriculum development. DACUM is used in many developed and developing countries.

C.3. Functional Analysis

Functional Analysis (FA) is not a method for occupational analysis in a strict sense. Rather, the idea is to start with the identification of the key purpose of an occupation in the major sectors where it is found, identifying the main functions, breaking these in turn down to subfunctions until outcomes for each function are identified following a strictly logical sequence. Functional Analysis, as practiced in the United Kingdom, uses a consultative process that involves practitioners, managers, and, in some cases, the users or consumers of standards. The modules are analyzed one by one to identify the performance requirements. The FA method has been used in several countries in Europe and the Middle East and is being experimented with in South America.

C.4. Pros/Cons and Comparisons of Different Approaches

All methods have their merits; therefore, one should not disqualify an approach before evaluating it against the desired outcome, resource constraints, and the setting in which the analysis will take place. None of the methods will produce totally reliable (consistent) results, as the processes remain somewhat subjective.

Comparisons of All Three Methodologies. Comparisons show distinct differences. First, using job analysis, repeated onsite observations are required to identify tasks, which can then be generalized to the occupation. This has resource implications and thus job analysis may cost more than DACUM and FA. Second, job / task analysis may be appropriate if the occupation involved is rather unique. For example, the occupation may be in a specific setting in the public or private sector, where failure to perform the task or job exactly as required carries a potential for considerable liability. Such occupations include public emergency services, health technicians, and nuclear power plant operators where there may be a strong rationale for job analysis rather than other approaches, which may produce more generalized standards. And, as noted previously, there are methods for identifying core skills and common occupational competencies between occupations from individual job analysis.

Comparisons between DACUM and FA. Comparisons show a degree of similarity in approach and resource requirements. First, the amount of resources committed to replicate the process is possibly less than with job analysis. Second, both DACUM and FA focus on work processes (either from the perspective of how occupations are performed or how they should logically be performed). Although both methods have solutions / mechanisms for linking the results of the analysis with training, the link in both cases may not be fully satisfactory for the design of training standards (see chapter eight). The DACUM map provides duties and tasks (competencies) performed in connection with each duty, whereas FA specifies key functions and individual functions that support them; both methods do the mapping to define performance requirements. The list of tools, equipment, materials, and supplies pertinent to the occupation identified during a DACUM workshop would be included in the range section of the Functional Map in FA. DACUM traits and attitudes are similar to overarching requirements in FA.

A considerable difference can exist between the concept of competence undertaken by FA and that used by DACUM. For the latter, a competency is the description of important tasks; at the same time, it is the sum of small tasks called subcompetencies. The totality of competencies makes up an occupation. However, FA does not describe the tasks; rather it identifies the results that are necessary to achieve the key purpose.

DACUM is perhaps a more straightforward bottom-up approach; it is more descriptive and therefore closer to traditional job/task analysis. Functional Analysis is more topdown, structured, technical, and perhaps more objective. The results from FA may be more reliable than DACUM, but it remains a subjective method. The deduction method that has to be followed for FA is more complex than the DACUM method.

D. Qualification Framework and International Standard Classification of Education

D.1. Bangladesh Technical and Vocational Qualification Framework

Bangladesh has not yet finalised national technical and vocational qualification framework (TVQF). Currently it is in progress. The draft version for the national TVQF is given in Table D.1.

D.1.1. Overview of the Proposed Bangladesh TVQF

Bangladesh National TVQF has 6 levels (Table D.1). They are described as below:

- The first two levels are for pre-vocational training. These two levels cater for the under-privileged groups and to the low education groups. The awards here are the National Pre-Vocation Certificate 1 & 2.
- The third level builds on the skills and knowledge received from the first two levels and provides a basic general introduction to what to expect in the workplace. This is the National Skill Certificate - 1 (NSC 1).
- Levels 2- to 5 are the 5 National Skill Certificates which provide the skills required to become a skilled and highly skilled craftsperson.
- Level 6, the Diploma level, is the premier TVET qualification and it is at this level that the future of Bangladesh competitiveness in the world is dependent on. It is this level that made Singapore what it is today.

The proposed framework provides an exit point at each of the levels for learners to exit into the workforce from fulltime studies. The framework needs to allow learners to continue their studies by supplying flexible delivery of programs.

Table D.1.: Proposed Bangladesh TVQF with associated level descriptors (Moore, 2009)

TVQF Level	Knowledge	Skill	Responsibility	Job Class.
6	• Comprehensive actual and theoretical knowledge within a specific study area with an awareness of the limits of that knowledge.	• Specialised and restricted range of cognitive and practical skills required to provide leadership in the development of creative solutions to defined problems	• Mange a team or teams in workplace activities where there is unpredictable change • Identify and design learning programs to develop performance of team members	Supervisor / Middle Level Manager /Sub Assistant Engr. etc.
5	• Very broad knowledge of the underlying, concepts, principles, and processes in a specific study area	• Very broad range of cognitive and practical skills required to generate solutions to specific problems in one or more study areas.	• Take overall responsibility for completion of tasks in work or study • Apply past experiences in solving similar problems	Highly Skilled Worker / Supervisor
4	• Broad knowledge of the underlying, concepts, principles, and processes in a specific study area	• Range of cognitive and practical skills required to accomplish tasks and solve problems by selecting and applying the full range of methods, tools, materials and information	• Take responsibility, within reason, for completion of tasks in work or study • Apply past experiences in solving similar problems	Skilled Worker
3	• Moderately broad knowledge in a specific study area.	• Basic cognitive and practical skills required to use relevant information in order to carry out tasks and to solve routine problems using simple rules and tools	• Work or study under supervision with some autonomy	Semi-Skilled Worker
2	• Basic underpinning knowledge in a specific study area.	• Basic skills required to carry out simple tasks	• Work or study under indirect supervision in a structured context	Basic-Skilled Worker
1	• Elementary understanding of the underpinning knowledge in a specific study area.	• Limited range of skills required to carry out simple tasks	• Work or study under direct supervision in a structured context	Basic Worker
Pre-Voc 2	• Limited general knowledge	• Very limited range of skills and use of tools required to carry out simple tasks	• Work or study under direct supervision in a well-defined, structured context.	Pre-Vocation Trainee
Pre-Voc 1	• Extremely limited general knowledge	• Minimal range of skills required to carry out simple tasks	• Simple work or study exercises, under direct supervision in a clear, well defined structured context	Pre-Vocation Trainee

D.1.2. Key Features of each Qualification Level

National Pre-Vocation Certificates: In the proposed TVQF model the first National Pre-Vocation Certificate NPVC 1 targets basic level literacy, numeracy and practical life skills. On successful completion of the course students will have the skills to contribute effectively to community life or to go on to further study.

The second National Pre-Vocation Certificate NPVC 2 concentrates on general and practical life skills to enable participation in:

- further education and / or training,
- self employment or paid employment, and
- work within the community.

On successful completion of the course, students will have the skills to contribute effectively to community life, or start their own business, or to go on to further study. Students have the opportunity to progress to the National Skill Certificate 1.

D.1.2.1. National Skill Certificate - 1

This is a very important qualification for the low educated and under-privileged sectors of society. This course provides the learner with the knowledge and skills to perform a defined range of activities, most of which may be routine and predictable.

Applications may include a variety of employment-related skills including preparatory access and participation skills, broad-based induction skills and / or specific workplace skills. The ability to work in a team environment is a major outcome for this course. Progression from this qualification to the SSC (Voc), year 9, may require a bridging program to raise the literacy and numeracy levels of the certificate holders.

D.1.2.2. National Skill Certificates - 2, 3, 4 & 5

The certificates can be delivered as stand alone programs and also provide the vocational component of the SSC (Voc) and HSC (Voc) programs of study. It is anticipated that NSC 2 & 3 will be embedded into NSC 4. Formal indentured apprentices, for example, could be enrolled directly into NSC 4 and effectively will complete NSC 2 & 3 as well as NSC 4 in their formal of-the-job training in a TTC or similar institution.

NSC 5 is the post-trade specialisation level. For example a craftsperson who has completed an electrical fitters course could complete a NSC 4 in instrumentation and control to broaden their skill-base and subsequently enhance their job opportunities. Similarly a machinist could complete a Computer Numerical Controlled (CNC) machining program to upgrade their skills.

D.1.2.3. Diploma in Engineering or Equivalent

The Diploma is the highest qualification in the technical education sector utilising CBT curricula. The following outlines the expected outcomes of a Diploma in Engineering or equivalent program of learning:

- the self-directed application of knowledge and skills, with substantial depth in some areas where judgment is required in planning and selecting appropriate equipment, services and techniques for self and others;
- breadth, depth and complexity covering planning and initiation of alternative approaches to skills or knowledge applications across a broad range of technical and / or management requirements, evaluation and coordination; and
- applications involve participation in development of strategic initiatives, as well as personal responsibility and autonomy in performing complex technical operations or organising others. It may include participation in teams including teams concerned with planning and evaluation functions. Group or team coordination and training is involved.

Job titles in this area would include technician, technical officer, sub-assistant engineer, associate engineer, assistant engineer as well as middle-level management titles.

D.2. The German Qualifications Framework for Lifelong Learning

The German Qualifications Framework for Lifelong Learning (known by its German abbreviation of DQR) represents the first comprehensive matrix for the alignment of qualifications. It extends across educational areas and acts as a considerable aid to navigation within the German educational system. For this purpose the DQR describes on eight reference levels professional and personal competences which direct the alignment of qualifications obtained in general education, higher education and vocational education and training (DQR, 2009).

The eight reference levels contained within the draft DQR each describe the competences required to obtain a qualification. The term competence constituting the heart of the DQR depicts the ability and readiness to use knowledge, skills and personal, social and methodological competences in work or study situations and for occupational and personal development. Competence is understood in this sense as action skills (ibid.).

D.3. The European Qualification Framework (EQF)

The European Qualification Framework (EQF) is meant to function as a common frame of reference for learning results and competence levels that should simplify the comparison of competencies and thus contribute to better recognition of existing qualifications. The EQF is conceived as a meta-framework, so that it can function as a translation tool between national frames of reference and the EQF to make national qualifications more readable across Europe, promoting workers' and learners' mobility between countries and facilitating their lifelong learning (ReferNet-Germany, 2009).

The core of the EQF are eight reference levels describing what a learner knows, understands and is able to do - 'learning outcomes'. Levels of national qualifications are to be placed at one of the central reference levels, ranging from basic (Level 1) to advanced (Level 8). It therefore enables much easier comparison between national qualifications and should also mean that people do not have to repeat learning if they move to another country (EQF, 2010).
The EQF applies to all types of education, training and qualifications, from school education to academic, professional and vocational. The system shifts the focus from the traditional approach which emphasises 'learning inputs' such as the length of a learning experience, or type of institution. It also encourages lifelong learning by promoting the validation of non-formal and informal learning (ibid.).

D.4. International Standard Classification of Education (ISCED 97)

The International Standard Classification of Education (ISCED) was designed by UNESCO in the early 1970s to serve as an instrument suitable for assembling, compiling and presenting statistics of education both within individual countries and internationally (ISCED, 1997).

ISCED 0 Vorschule
Die Programme bilden den Anfang des organisierten Unterrichts bis zur Primärschule. Sie finden in Schulen oder Zentren statt und werden für mindestens 3 Jahre alte Kinder angeboten.

ISCED 1 Primarstufe
Die Programme sind obligatorisch und beinhalten das systematische Lernen aller drei Grundfertigkeiten Lesen, Schreiben und Rechnen sowie eine Einführung in die Grundlagen anderer Fächer. Kinder im Alter zwischen 5 und 7 Jahren besuchen diese Programme während 6 Jahren.

ISCED 2 Sekundarstufe I

Die Programme dieser Stufe sind ebenfalls obligatorisch. Sie schliessen an die Primarstufe an und komplettieren die Basisausbildung. Die Programme sind schwergewichtig fächerorientiert. Der Unterricht wird in mehreren Fächern durch Fachlehrkräfte erteilt.

ISCED 3 Sekundarstufe II

Die Programme dienen der Ausbildung nach der Basisausbildung, sie beginnen ca. 9 Jahre nach Beginn der Primarschule. Sie setzen als Minimum die Kompetenzen voraus, die am Ende der Sekundarstufe I erworben sein sollten.

Unterscheidungen:

1. nach Programmtyp: die Programme werden danach unterschieden, ob sie zum Hochschulbereich (A), zur höheren Berufsbildung (B) oder zum übertritt ins Erwerbsleben (C) führen. Dabei wird die kumulierte theoretische Dauer seit Beginn der Sekundarstufe II berücksichtigt: in 3A oder 3B klassierte Programme müssen insgesamt mindestens 3 Jahre dauern. 2. nach Programmorientierung: es werden allgemein bildende von berufsbildenden Programmen unterschieden.

ISCED 4 Zweitausbildung nicht-tertiäre Stufe

Diese Programme bieten eine Ausbildung nach der Sekundarstufe II ohne tertiären Inhalt; sie setzen einen erfolgreichen Abschluss von mindestens 3-jährigen Programmen der Stufe ISCED 3 voraus. Sie werden gleich unterteilt wie die Programme auf Stufe 3.

Die Stufe ISCED 4 muss nicht von allen durchlaufen werden, die eine Bildung auf der Tertiärstufe anstreben. Sie stellt sozusagen eine -Zusatzschlaufe- dar.

ISCED 5 Tertiärstufe I Die Programme bieten eine Ausbildung mit tertiärem, das heisst deutlich fortgeschrittenerem Inhalt; sie setzen einen erfolgreichen Abschluss von ISCED 3A oder 3B, resp. 4A oder 4B voraus; ihre theoretische Dauer seit Beginn der Stufe 5 ist mindestens 2 Jahre. Die Programme werden unterschieden in 5A und 5B nach der Art der anschliessenden, darauf aufbauenden Bildung, d.h. ob sie Zugang zur Stufe 6 geben, nach der inhaltlichen Ausrichtung der Programme (unterschieden werden wissenschaftsbasierte high skill professions versus praktisch / berufsorientierte) sowie nach der kumulierten theoretischen Dauer seit Beginn ISCED 5.

ISCED 6 Tertiärstufe II

Die Programme bieten eine Ausbildung für eine fortgeschrittene Forschungsqualifikation; sie setzen den erfolgreichen Abschluss von ISCED 5A voraus; im Verlauf der Ausbildung verfassen die Studierenden eine Dissertation von publizierbarer Qualitt basierend auf eigener Forschung.

E. Glossar: Englisch – Deutsch Übersetzungen

Einige Englisch – Deutsch Übersetzungen

action based learning-teaching – Handlungsorientierter Unterricht

action-oriented learning-teaching (BIBB) / practice-oriented learning-teaching (GTZ) – Handlungsorientierter Unterricht

commercial-technical trainings fields – gewerblich-technischer Ausbildungsbereiche

comprehensible – verständnisorientiert

decisive factors – Entscheidungsfelder

directive subject-systematic / traditional teaching – direktiv-fachsystematischer Unterricht

discriminatory power – Trennschärfe

examinee – der / die Prüfling

framework curriculum – Rahmenlehrplan

general character and personality – allgemeine Persönlichkeitsmerkmale

handbook – Tabellenbuch

holistic - ganzheitlich

ibid. – ebd.

in-depth - tiefergehend

“inert knowledge” – der Fachbegriff für träges Wissen, also jene Art von Wissen, das zwar im Gedaechtnis vorhanden ist, aber vom Lernenden nicht angewendet wird (oder angewendet werden kann)

justified – begründet

occupational activities – berufliche Handlungen / berufliche Tätigkeiten

occupational competence – berufliche Kompetenz, Handlungskompetenz, berufliche Handlungskompetenz, berufliche Handlungsfähigkeit (BIBB)

“omnivores” – “Allesfressers”

overburdened – überfordert

overburdening – Überforderung, excessive demand

professinal competence – fachliche Kompetenz / Fachkompetenz

professional competence – Fachkompetenz (DQR, 2009)), also technical competence professional / occupational qualification – berufliche Qualifikation

regardless – ungeachtet

selection of methodology – Methodenwahl

self-directed action-oriented learning-teaching / self-directed practice-oriented learning-teaching – selbstgesteuert-handlungsorientierter Unterricht

spell sth out – to explain something in a very clear way with details

superficial – oberflächlich

target group – Zielgruppe

technical competence – fachliche Kompetenz / Fachkompetenz

training occupation , occupation requiring formal training, apprenticeship training oder apprentice training – Ausbildungsberuf

Training regulations – Ausbildungsordnung

workplace relevant qualification – berufsspezifische gegenstandsbezoge Qualifikation

work-related social competences – arbeitsbezogene soziale Kompetenzen

Explanation of Keywords

competence – the "competence" as used in this work, is merely a general term covering knowledge as well as practice / skills, and has no necessary implications of a competence-based training or assessment scheme.

Curriculum Vitae

Faruque Ahmed Haolader, Wilhelmastr. 9, 70376 Stuttgart

Bio-data

02.01.1963	Born in Barisal, Bangladesh

Education and work experience time-line

1980–84	Study at Barisal Polytechnic Institute, Bangladesh Diploma-in-Engineering (Electrical Technology)
1984–86	Junior Instructor (Electrical) at Polytechnic Institute, Bangladesh
1986–92	Study at Bangladesh Institute of Technology (BIT) Dhaka, Bangladesh Bachelor of Science in Engineering (Electrical & Electronic) Teacher Training (UNESCO Fellowship programme) at NTTTI, India
1992–94	Instructor (Electrical) at Polytechnic Institute, Bangladesh
1994–96	Lecturer (Electrical & Electronic) at Technical Teachers' Training College (TTTC), Dhaka, Bangladesh
1995–96	Study at the University of Birmingham, The United Kingdom Master of Science (Engineering) (Electronics and Information Technology) Training at Bolton Institute, LJ Technical Systems and ABB, The UK.
1996–98	Instructor and Head of Electrical Department at Polytechnic Institute, Bangladesh
1998–99	Computer Programmer at the Ministry of Planning, Government of Bangladesh
1999–2001	Study at Dresden University of Technology, Germany Research Assistant at Fraunhofer Institute for Transportation and Infrastructure Systems (IVI), Dresden, Germany
2001–05	Research Fellow at Fraunhofer Institute for Transportation and Infrastructure Systems (IVI), Dresden, Germany
2005–10	PhD candidate at the University of Stuttgart, Germany Engineer (Design & Development) at DINA Elektronik GmbH
July 2010	Dissertation Technical and Vocational Education and Training – Curricula Reform Demand in Bangladesh. Qualification Requirements, Qualification Deficits and Reform Perspectives

Expected degree: Doctor of Philosophy (Dr. phil.)

Scholarships/Fellowships

UNESCO Fellowship for Technical Teachers' Training in India
Bangladesh Government Scholarship for under-graduate study
BTA Scholarship for post-graduate study in the United Kingdom
DAAD Scholarship for post-graduate study in Germany

Membrship of Professional Bodies

Fellow, Institution of Engineers Bangladesh (IEB), Bangladesh
Member, Bangladesh Computer Society (BCS), Bangladesh
Member, The Institute of Electrical & Electronic Engineers (IEEE)
Member, UNESCO-UNEVOC e-Forum

Publications

F. A. Haolader. TVET Systems and Technical Teachers Training Model of Bangladesh. Proceedings of the 3rd International Symposium on Technical and Vocational Education (TVE) Systems and Technical Teachers Training Model in Developing Countries. Beijing, China, September 25 -30, 2004.

F. A. Haolader, N. Moehler, W. Oertel and M. Rueder. Video-based Approaches for Onboard Obstacle Detection on Railroad. Zel 2004 - 11th International Symposium on European Railway, Zilina, Slovakia, May 27 -28, 2004.

S. Funck, U. Spengler, C.W. Brock, F. A. Haolader. Increased Security and Operating Efficiency by Automatic Train Interior Inspection. The World Congress on Railway Research, Edinburgh, UK, 28 Sept. - 1 Oct. 2003, pp. 1498 - 1503.

M. Rueder, N. Moehler and F. A. Haolader. An Obstacle Detection System for Automated Trains. IEEE IV2003 Intelligent Vehicles Symposium. Columbus, Ohio State, USA, June 9 -11, 2003, pp. 180 - 185.

F. A. Haolader. Linkage Between Technical-Vocational Education and Production and Service Structures - Consequences for the Technical-Vocational Teachers Training in Bangladesh. 2nd Alumni Workshop of Vocational Education Dept., Technische Universität Dresden, Germany in Vientiane, Laos, 16 - 26 Sept. 2002.

F. A. Haolader, H. Simmert and W. Ihbe. Technical and Pedagogical Aspects in Designing & Developing Teaching /Learning Environment - Prototypical Realization of ISO-OSI 7-Layer Model. In: Realities in Science, Mathematics and Technical Education, 2001, ISBN 99917-1-078-7. The University of Brunei Darussalam.

F. A. Haolader. Microprocessors and Interfacing. A textbook of Bangladesh Technical Education Board. Gyanokosh Publishers, Bangla Bazar Dhaka, 1998.

Eidesstattliche Erklärung

Ich erkläre, dass ich die vorliegende Arbeit selbstständig und nur mit den angegebenen Hilfsmitteln angefertigt habe und dass alle Stellen, die im Wort oder dem Sinn nach anderen Werken entnommen sind, durch Angabe von Quellen als Entlehnung kenntlich gemacht worden sind.

Md. Faruque Ahmed
Stuttgart, den 23.12.2010