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Higher Education Systems: Postsecondary Vocational & Technical Education Developments in Comparison

Peter A.J. Englert and Wolf Dieter Grossmann
University of Hawaii
USA

1. Introduction

Key parameters of modern change processes in many economies and societies are the growth of knowledge and global digital information potential, major drivers for the move towards innovation or knowledge society. The influence of these drivers on higher education is remarkable and will provide a challenging framework for development opportunities of higher education systems and institutions. A major element of change is the explicit or implicit mandate to regional and national higher education systems of social relevance and alignment with economic development. Higher, i.e. post-secondary vocational & technical education has teaching, learning and degree structures that are generally and intuitively well aligned with a polity's economy or economic development strategy. However, structure, depth and breadth of higher vocational & technical education are very different for different educational cultures based on the polities' historical social and economic development trajectory. In this chapter an analysis of knowledge and information growth and its effects on vocational & technical post-secondary education will evaluate current organizational characteristics as well as degree structures of different educational cultures, including New Zealand, the United States of America, China, and Germany. Qualitative comparative analysis will provide suggestions for future development opportunities of higher technical & vocational education as a key element for the construction and development of innovation or knowledge society. The role of post-secondary vocational & technical institutions in life-long learning, continuous human resource development, and workforce education will be briefly discussed. Opportunities of vocational & technical education as a major access portal to other forms of higher education for large parts of polities will also be considered.

Higher education, for many centuries and in may cultures a privilege of the few, has with the onset of the Industrial Revolution in the Western world and over time become a major factor in the development of nations and their economies, and therefore by necessity accessible to large fractions of populations around the globe. The history of vocational, technical, and professional education, for a long time separate and not part of higher

education, and its subsequent integration or not into the post-secondary higher education environment is a worthwhile subject for detailed analysis in different education cultures.
The knowledge and information content of almost all human activities, including social and economic activities has dramatically changed. In the higher education environment several trends are reflecting this change: The transformation, e.g. in the United States of America into pre-professional and professional degrees of what were previously liberal arts degrees or research based precursors of academic doctoral degrees manifest some of these changes. This trend is highlighted by the significant growth in abundance and number of pre-professional and professional degrees awarded, especially of professional master's degrees and, to a much lesser extent, professional doctorates. The drivers for these developments are also the drivers for the further advancement of vocational & technical education and hence, the progressive integration of vocational & technical education into post-secondary education systems in many education cultures is another change indicator.
The intent of this chapter therefore is, to evaluate through qualitative comparative analysis effects of these macroscopic drivers of change on the location and position of vocational & technical trajectories within frameworks of education, the associated scholarship and research & teaching content, and the development of degrees in vocational & technical institutions within post-secondary education systems.

2. Higher Vocational & technical Education in Postsecondary Systems

There are many different higher education cultures present in the major regions of the globe. Many of these cultures have developed as a result of the growing and changing needs of societies in line with their historical and economic development. Today, and as a result of growth in content and knowledge, higher vocational & technical education is firmly embedded in several higher education systems and cultures. The location of vocational & technical education within education systems, its position within systems of higher education, and its functions in economy and society shows a large variation of approaches between countries. A first attempt of understanding these different approaches would be to find the general location of vocational & technical education within education and its position within higher education systems.
There are many different ways of describing higher education systems. For the purpose of higher vocational & technical education we need measures of fit between the activities of higher education systems and areas of economic activity. Therefore geographically and politically defined areas, such as national economies, or local & regional state economies with some economic autonomy will provide a useful framework. Both public and private higher education providers contribute through their activities to a given national or regional economy, whether they are aggregated into statutory systems of higher education for reasons of convenient administration or not. The most common areas of study should be national economies and national higher education systems.
There are many different and sometimes very sophisticated classification systems for higher education and its institutional components (McCormick & Zhao, 2005). For the purpose of this chapter the general components of higher education systems can be classified by the type and content of education provided, such as general, professional or vocational & technical, and degrees granted.

This classification is simple as it needs to be applicable to almost any higher education system around the globe. Experience shows a large degree of variation across countries.

- Non-baccalaureate institutions
  - General
  - Professional
  - Vocational &Technical
- Baccalaureate institutions
  - General
  - Professional
  - Vocational &Technical
- Comprehensive Masters institutions
  - General
  - Professional, Vocational &Technical
- Comprehensive Doctoral institutions
  - General
  - Professional
- Specialized post-graduate institutions
  - General, Professional

Implicit in this characterization is that vocational & technical signifiers transform into those of professional education as degree level increases. At doctoral institutions professional degrees constitute only a minority of those awarded except in areas such as medicine and law. Furthermore, within the framework of national definitions, professional and vocational & technical education is frequently not considered to be part of higher education, especially at the non-baccalaureate level, but sometimes also at the baccalaureate level. On the other hand, general education providing units at the non-baccalaureate level are sometimes considered to be part of higher education systems. For the purpose of a comprehensive framework, professional and vocational & technical education needs to be included in the analysis of all higher education systems when its curricular structure clearly exceeds basic skill training, whether it is formally considered so or not.

3. Knowledge and Information Potential Growth

Of the major sources that influence the future development of higher education: knowledge and information potential growth was, is and will be a significant driving force (Duderstadt, 2000; Katz, 1999). In addition, the growth in information potential has emerged as a major driver of economies. One of the key results of knowledge growth is the history of the development of higher education itself, the creation of disciplines and the establishment of ever more disciplines over time as well as the differentiation of categories of higher education institutions.

3.1 Knowledge Growth

Knowledge growth is frequently characterized by the time it takes for valid and not redundant or obsolete knowledge of a field or society to double. The time constants provided for one doubling of human knowledge vary significantly with academic discipline or other knowledge field, and are generally assumed to be between 5 and 14 years. Aspects

of knowledge growth were discussed almost twenty years ago. Key publications by Romer, Stern, and Castells give an early comprehensive description of the development of knowledge society (Romer, 1990; Stern et al., 2000; Castells, 2000a, 2000b, and 2004).

In higher education we see several effects of knowledge growth. More and more qualified workers are required in private and public enterprises, and polities encourage investment supporting the participation of larger fractions of their populations in higher education.

Knowledge does not only grow, also the knowledge about changes of knowledge evolves very rapidly. This directly affects education institutions of all types, as they have the creation and transmission of knowledge as one of their main elements. An example of knowledge about knowledge change is direct and fast access through the Internet to scientific journals, another is search through search engines, general ones such as Google as well as those for scientific papers, e.g. through Google Scholar. Whereas we can expect that this new development will accelerate, even present knowledge about knowledge changes does only slowly become effective. It is moderated by a multitude of factors, e.g. administrative, political, organizational, slow learning and human difficulties. For example, all scholars should be engaged in using such possibilities, but observation shows that this is not yet the case.

Knowledge also grows through combination of different types of knowledge. This has two effects, one, it further accelerates knowledge growth and the other is that it makes knowledge more complex. For example, a sophisticated combination of knowledge bodies has brought about Geographical Information Systems (GIS). The more advanced GIS have features which can only be used by highly trained, large and specialized groups – something which higher education institutions by their nature cannot easily provide. Particular examples of combinations of knowledge bodies include interdisciplinary fields such as the new genomics. As higher education institutions in general have difficulties in interdisciplinary synthesis they face the risk that they are increasingly left behind by external providers and their service and software packages.

A conceptual presentation may be useful in demonstrating a particular effect of the increasing volume and diversity of knowledge which will greatly influence the structure of education institutes and their relationship to each other. This phenomenon is outlined in Figure 1. It shows the increasing separation between originally related fields of knowledge.

In reality and from a holistic point of view, everything is connected with everything else, although not everything is closely connected with everything else. Thus, Figure 1 demonstrates an increasing necessity for co-operation between different fields of knowledge, to keep knowledge relevant. Accordingly, it becomes increasingly more necessary for higher education institutions to co-operate, even if their scope and mission seem to be very different. With further growth of knowledge, an individual education unit or country can cope ever less with the total amount of knowledge which further increases the necessity for co-operation at many different levels.

Other effects of knowledge growth on higher education areas arise in the field of business. As demand for knowledge workers increases and as knowledge acquisition and creation becomes more complex, higher levels of accomplishment and degrees are required for occupations and professions. More and higher levels of specialization have appeared, and new and mostly higher forms of qualifications emerge (Englert, 2007).

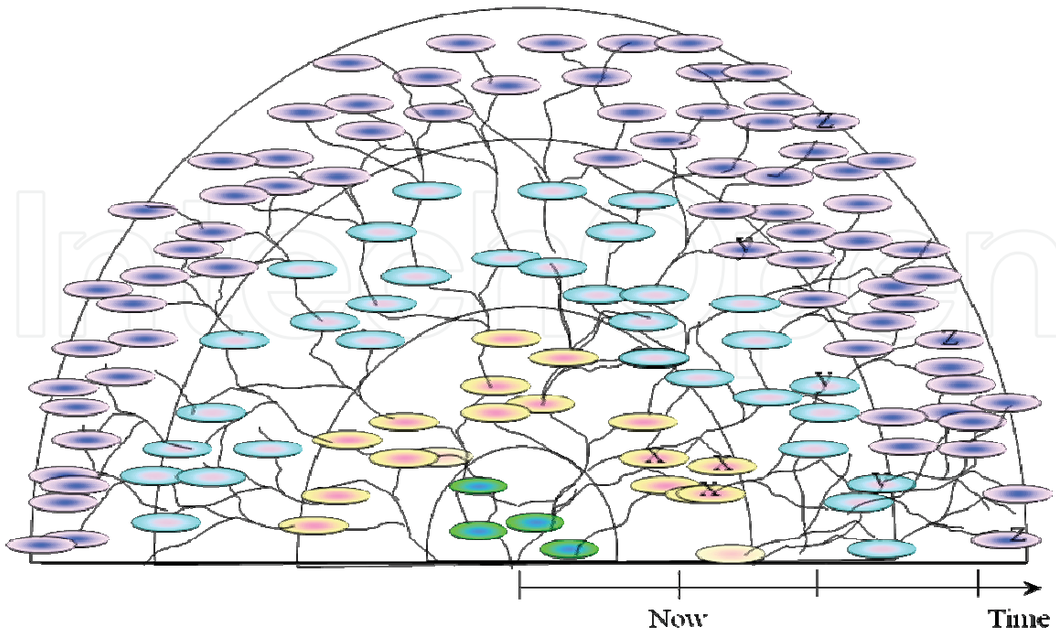

Fig. 1. Increase in number of knowledge fields over time and their resulting increasing separation. Here, x, y, z are knowledge fields that were initially related (x), but they evolve (y) differently and become increasingly disparate (z). This Figure, in principle, also indicates the relative growth of knowledge useful for the four economic macro sectors, with the innermost half sphere representing the 1st sector, the next half sphere the 2nd sector and so on.

Statistics on participation rates in higher education are published by national and international agencies. The growth in participation in higher education is evident in almost all polities of the globe, developed and developing countries. From 1991 to 2004, global participation in higher education grew from 68 Million to 132 Million, or almost by a factor of two (UNESCO Institute for Statistics, 2006).
Within higher education in many economies the bachelor's degree was and is the terminal preparatory degree for many occupations and participants. However, the growth of knowledge created and the knowledge required to fulfill professional functions in modern economies is leading to a growth in Master's degree development and enrollment. A further trend indicating knowledge growth and its reflection in the appearance of new advanced degrees is seen in professional doctorates (Englert, 2007).

3.2 Information Potential Growth

Information and digital communication are now globally prevalent and available. High-information-products, information-rich and communication intensive products and services, are currently developing fast (Ernst, 2005). As a result, information and information technology enters many established goods and services and changes their nature. Consequently, information content and knowledge requirements are growing in all economic sectors including goods production and service sectors, and that is where higher vocational & technical education plays a major role.

According to Dyson (Dyson et al., 1994), the large-scale availability of information is, in its effects on human societies and economy, comparable to the transition from the agricultural to the industrial age when, due to the steam engine, a big supply of energy could be accessed, i.e. fossil coal.

3.3 Knowledge and Information in Economic Sectors

Economic changes resulting from effects of knowledge and information potential growth drivers can be assessed by sketching their effect on economic macro sectors. The term "sector" is used with two meanings in economics: the first meaning is the multitude of well-established 'general sectors' such as retailing, wholesaling, computer manufacturing or telecommunications, and the second meaning concerns four "macro-sectors". The 1st sector is the primary products and resources sector and contains in particular agriculture, forestry, fisheries, and mining. The 2nd sector is classical goods production or manufacturing. The 3rd sector contains service products, including diverse services from health care to tourism. As large amounts of information are becoming a major resource it can be observed that within all classical sectors products and services are developed which are very high in information content and/or transportation of information and knowledge and could be defined as the 4th macro-sector. Examples are: multimedia products, Experience Economy (Pine & Gilmore 1999), the Internet, networks for cellular phones, or nanotechnology

In addition, the emergence of knowledge and information rich products and production modes sees the rise of a new workforce, called "highly qualified people" in many publications of the OECD (e.g. OECD Publishing, 2008), a phenomenon which was basically already described by Schumpeter in 1939 for the 1920s wave of basic innovations. Castells gave an early comprehensive description of the development of the knowledge society (Castells 2000a, 2000b, and 2004). Grossmann (Grossmann, 2001) describes strategies for regional development in the information society and provides systems models for their description with some real applications to planning and management.

The concept of information-rich and communication intensive products and services asks for workforce education that can adapt to this changing and increasingly more complex environment. The opportunity but also increasing responsibility of providing this workforce lies clearly in the area of higher education. This leads to conflicts with established education and requires a partial transformation of higher education.

3.4 Example: Textile Industry

In China and in many other countries of Asia the development of classical goods production was considered the most important driver in transforming primary production based agricultural societies into modern ones. In India as well as in China increases in knowledge

based services including innovation also play a major role in the transition (Ernst, 2006). As discussed above, knowledge and information potential are transforming both goods production and services by enriching both macro-economic sectors through changing established products into information rich and communication intensive ones, through creating new ones, and through changing production and supply processes (Farrell, 2003).

For many developing countries the transfer of textile production from Europe and North America played a major role in building Gross Domestic Product and personal income. Basic drivers were initially production cost considerations and low-wage workforce availability for classical and labor intensive production establishments. This paradigm has changed under conditions of knowledge and information potential growth. Moazzem (Moazzem et al., 2007) argues that textile production in Bangladesh since its inception in the early 1980s has developed with support of different international policies, such as the Multi-Fiber Arrangement (MFA), a Generalized System of Preference (GSP), and various policies at the domestic level. With the membership of China in the World Trade Organization and the phase out of the MFA in 2005, a number of challenges are confronting the apparel sector of Bangladesh. In the changing scenario, it has been projected that without having product diversification by applying more advanced technologies, Bangladesh would be unable to retain its market share. Moazzem continues to argue, that 'in order to be competitive in the global market, apparel exporters of Bangladesh have to reduce lead time, ensure 'lean retailing', provide support of full supply chain, have the capacity for supplying bulk volume of orders, develop compliance standard and take measures for workers health and safety'.

While implicitly recognizing some elements of the potential impact of knowledge and information potential growth in this industry, the analysis is far from complete. To the contrary and in extension of major arguments of this chapter, De Raeve (De Raeve, 2007) sees the development of textile products in an urgent need for adequate knowledge circulation, and for faster and more effective translation of scientific results into innovative commercial products. Information potential adds the dimension of more flexible small batch oriented manufacturing processes that allow a better consumer orientation through 'mass customization'. This is a clear argument for the transformation of the industry from a resource base to knowledge and information influenced base. And while this analysis was undertaken from a European point of view it does have general validity.

These tensions are present in all aspects of goods production and service provision environments and require significant flexibility in educating and preparing a workforce that can embrace these and predicted future changes. Therein lays a challenge and opportunity for higher vocational & technical education.

The European textile industry viewpoint shows that in current circumstances economies with an interest in stability may need to consider regaining strength in advanced goods production and services. Given that wage differentials for an advanced workforce diminish in international comparison, the increasing presence of such a workforce is, among others, a key factor in determining location and establishment decisions for goods production and service sector companies. This provides an additional reason for giving serious consideration to strengthening or, in some circumstances, re-developing and almost re-inventing higher vocational & technical education.

4. Location and Position of Higher Vocational & Technical Education

The location of vocational & technical education within an education system and the position of higher vocational & technical teaching institutions and their present functions in frameworks of education systems are very much dependent on development histories and the societal purposes they were originally established for. In some educational cultures vocational & technical education is introduced in compulsory education before transition into specialized skills training or higher education. Vocational & technical secondary education trajectories are not always constructed to provide access to higher vocational & technical education or to higher education in general. This may be by design or for historical reasons. An analysis of position and location of vocational education may find reasons for this status or arguments for change.
A comparative analysis of different education cultures may be helpful in evaluating aspects of existing paradigms and future development trends.

TYPE OF EDUCATION	PR CHINA		USA		NEW ZEALAND		GERMANY		
	U	V&T	U	V&T	U	V&T	U	V&T	
Pre-school	3		4		2		(3)		
Compulsory Primary Education	6		6		6		4+2		4+2
Compulsory Junior Secondary School	3	3	3		2	2	6/7	5	4
Senior Secondary School (compulsory in some countries)	3	3	3		4/5	3		2/3	(3)
Higher Education First Degree	4	3/4	4	2	3	2/3	5	3/4	2/3/4
Higher Education Second Degree	3		1-3		1-3	1-3		2/1	2/1
Higher Education Highest Degree	3		4-6		4-6		1-5+	3	

Table 1. Location and position of vocational & technical education in different countries

Due to the complex nature of the subject only general trends can be considered, sometimes leading to simplified statements.
The first column of Table 1 indicates the levels of education provided in each of the countries, including compulsory education and higher education. The subsequent columns describe parts of the education system that are general and provide access to general higher education indicated by 'U' and those that can be considered vocational and technical indicated by 'V&T'. Although there seems to be a seamless transition between secondary and higher vocational & technical education, this is not consistently so. The complexities are alluded to in the following chapters.
It is also important to observe where decisions are made about educational systems and where oversight lies in broad terms. Table 2 provides a comparison of some indicators

on accreditation and coordination of higher vocational & technical education (IAU, 2008). The oversight over education in general and over vocational & technical education is highly variable between countries. In the United States of America, the several States do have authority over all forms of education. Coordination and accreditation in general is therefore regional or even local. In New Zealand, all forms of higher education are centrally coordinated through the Tertiary Education Commission (TEC), while accreditation of programs for all non-university education, i.e. also for higher vocational & technical education is provided by the New Zealand Qualifications Authority (NZQA). In China, provincial Departments of Education or Municipal Commissions are responsible for the regionalized Vocational & Technical Colleges, while programmatic oversight still lies with

COUNTRY	INSTITUTIONS	ACCREDITING AGENCY	COORDINATIO N AGENCY
PR CHINA	VOCATIONAL/TECHNICAL COLLEGES (JUNIOR COLLEGES)	REGIONAL	CENTRAL
GERMANY	UNIVERSITIES OF APPLIED SCIENCE OTHER	REGIONAL CENTRAL	REGIONAL REGIONAL
UNITED STATES	ASSOCIATE COLLEGES COMPREHENSIVE UNIVERSITIES	REGIONAL	REGIONAL
NEW ZEALAND	INSTITUTES OF TECHNOLOGY POLYTECHNICS	CENTRAL	CENTRAL

Table 2. Vocational & technical education institutions, accreditation and coordination

the central Ministry of Education. The situation is more complex in the Federal Republic of Germany. There the several states have overall authority over almost all education including universities of applied sciences and their higher vocational and technical teaching. However, other forms of vocational & technical education are regulated (but not coordinated) by the German federal government. This applies to forms of higher vocational & technical education not associated with universities of applied science. In general, regionalization or centralization of accreditation or coordination of higher vocational & technical education can influence the effectiveness and flexibility of its delivery.

4.1 Location of Higher Vocational/Technical Education

Compulsory primary education is available in China, the United States, New Zealand and Germany for almost identical time frames and age groups (IAU 2008). The exception from the canonical starting at age six of compulsory primary schooling in the group of national economies compared is New Zealand. Here compulsory primary education begins at the age of five.

The length of compulsory primary education for all countries is six years. A specific commonality between them is that compulsory primary education is comprehensive, i.e. no occupation oriented curricular activities or directions are offered. The first major differentiation occurs therefore at the transition to junior middle school, i.e. to secondary education. China offers a special vocational & technical education track to students beginning at the age of twelve. The United States and New Zealand continue comprehensive, i.e. non-specialized schooling for all students until the end of senior middle

school, with a few specialization options through electives in vocational & technical education and other areas during the last years of schooling (Pucel, 2001).
The situation in Germany is more complex. Junior and senior middle schools leading directly to university and university of applied sciences admission can have a general humanistic or strong mathematics and science orientation, but not usually a technical one. The situation is different in the four year junior middle school environment, not directly leading to higher education access, which has generally a more technical and professional orientation. A further five year junior middle school track offers opportunities with vocational, technical, and professional orientation. The minimum compulsory schooling in Germany (not including three years of schooling during professional/ vocational/ technical apprenticeship) is nine years. Students transferring from the latter two middle school tracks into a higher education access track do not generally have opportunities to continue vocational & technical subjects during the last two/three years of secondary schooling.
As a result, China and Germany have cohorts of students prepared in vocational & technical subjects leaving senior middle school with the option of entering higher technical education. In both countries, students from non-technical tracks can also qualify for higher vocational & technical education. In China all students have to pass national examinations to obtain placement options within the Chinese higher education system. The United States and New Zealand students who have completed secondary schooling obtain access to the different types of higher education on the basis of choice and general scholastic achievement. Prior exposure to technical or vocational skills training is not required to enter higher technical education. In Germany, as in China, students with some technical training at the middle school level tend to enroll in higher technical education institutions, but prior technical education is not a requirement for admission.
Generally, in all education systems there is no direct connection between skills based vocational & technical subjects and higher education options in this area.

4.2 Position and Function of Higher Vocational & Technical Education

Post-secondary education in the United States does not have an easily distinguishable or identifiable higher vocational & technical education environment. The United States structure has a variety of post-secondary educational institutions with different missions, yet no clearly identified vocational & technical sector. Several States that are interested in attracting and maintaining goods production as part of their regional economy may have vocational & technical education options integrated in their higher education system. One example is the State of Tennessee which operates two higher education systems, the University of Tennessee system, and the system operated by the Tennessee Board of Regents, the latter established in 1972 also including 27 regionally distributed Tennessee Technology Centers providing certificates and diplomas for workforce development. Although operated by a higher education system, it is not clear how these centers address higher vocational & technical education aspects.
Among the more than 4000 accredited United States institutions of higher education there are some that could be considered technically oriented, frequently carrying the name 'Technical Institute'. But most of those are baccalaureate institutions, i.e. universities by definition, offering general four year Bachelor degrees and post-graduate degrees in many areas, including technical ones.

In comparison, higher vocational & technical education has a special place in China, New Zealand, and Germany. In China, three year Vocational & Technical Colleges and three and four year Technical Colleges can easily be identified as the major location of higher vocational & technical education. In New Zealand Institutes of Technology and Polytechnics, (and to some degree Industry Training Organizations) provide higher vocational & technical education through two and three year curricula, the latter being similar to Bachelor degrees in New Zealand universities in learning content and scholastic achievement. In Germany, in general terms, the primary location of higher technical education, other than that provided by research level Technical (Engineering) Universities are the Fachhochschulen (universities of applied sciences), which teach predominantly at the diploma, bachelor and master's level, and also the applied science environments of 'Gesamthochschulen' (comprehensive universities). But also 'Fachschulen' (professional schools) and 'Berufsakademien' (professional academies) provide higher vocational & technical education through multi-year (two or three year) curricula. It needs to be mentioned that much skills based but also advanced vocational & technical education in Germany occurs outside the higher education framework. Content and achievement of these vocational, technical, or professional education opportunities would warrant formal inclusion into higher education by standards in other educational cultures. Therefore, higher technical education in China, New Zealand, and Germany is well positioned at the end of secondary schooling and occupies well defined positions in the respective national higher education systems.

United States institutions providing post-secondary, but not specifically higher vocational & technical education, are Associate Colleges, commonly called Community Colleges. Public Associate Colleges provide to a significant degree vocational, technical and professional training through credit and non-credit courses. For example, Honolulu Community College in the State of Hawaii teaches technical courses for apprentices in auto mechanics, sponsored by trade unions. In addition, Associate Colleges provide a significant fraction of remedial non-credit courses and opportunities for adult education. The highest terminal degree offered by Associate Colleges is the two-year Associate degree. Course content and accomplishments are not always equivalent to that of higher vocational education in other cultures.

Public and private Associate Colleges however, have an additional and very important function, namely to teach at university level up to two years of required and elective courses that allow students, provided their achievements are high, to seamlessly transfer into universities. This access role is unique to US higher education and is an important part of the Associate College mission. In comparison and as part of their present specific focus, Vocational & Technical Colleges and Technical Colleges in China, Technical Institutes and Polytechnics in New Zealand, and Universities of applied science and other higher technical education academies in Germany do not have a mission based role of providing access to other forms of higher education such as universities, though in some cases vocational & technical credit can be applied towards achieving university bachelor degrees via self-study pathways or through adult and continuing higher education.

From this analysis one can derive that the higher vocational & technical education role in the US must therefore be partially or completely covered by four year baccalaureate and comprehensive master's degree institutions, i.e. four year colleges, master's universities, and sometimes even research universities. Predominantly publicly funded United States institutions at all levels have an obligation to respond to workforce education and workforce

development needs of their states. In general these institutions accept their regional role and provide for the majority of professional education needed regionally for public and private enterprises. The majority of public four year higher education institutions in the US have therefore mission elements that should address professional, vocational, and technical education.

4.3 Diversity of Approaches

One of the key questions arising from the diversity of vocational & technical education approaches is where most effectively to locate higher technical education within an educational pathway and where to position higher vocational & technical education within a system of higher education. Due to increasingly rapid progress of technology and science, the additional question emerges and is becoming highly important how education providers will be evolving their curricula to follow these developments in a timely fashion. One general answer lies in the mission of higher education institutions.

The missions of research universities are clearly defined across many education cultures by the 'scholarship of discovery' paradigm, which means 'research' and includes (but is not limited to) 'commitment to knowledge for its own sake, to freedom of inquiry, and to following, in a disciplined fashion, an investigation wherever it may lead' (Boyer, 1997). Such a paradigm has proven to develop science and technology well, but this does not apply to all areas of knowledge production. The missions of other components of higher education systems are well defined in some education cultures but not in others.

Table 3 provides a brief overview over some macroscopic data on higher vocational & technical education. The data are described and explained in the chapter text, again indicating that the complexity of national higher vocational & technical education environments cannot be compared without difficulty.

In China, the development of higher vocational & technical education through independent, local, and university associated vocational & technical colleges is a logical consequence of its

	PR CHINA	GERMANY	NEW ZEALAND	USA
POPULATION (M)	1.329	82	4	300
HIGHER V/T INSTUTUTIONS	872	213	19 (52)^	1.086*
HIGHER V/T ENROLMENT (M)	5.957	0.56	0.162	6.370
STUDENTS/INSTITUTION	6830	2630	8520 (3115)^	5865
TOTAL HE ENROLMENT (M)	13.33	1.94	0.503	13.33*
% V/T STUDENTS	44	29	39	48

Table 3. Higher Vocational & Technical Institutions in 2004. (*public sector institutions only, ^number of campuses, (M) Million; data references are provided in the text)

social and economic development based on goods production and services in addition to the primary sector, and the increasing knowledge and information content in these macroscopic economic sectors (Dai, 1991a; Dai, 1991 b; Cheung, 1996). Policy encouraged the mission of higher vocational & technical education in supporting regional and local industrial development through devolving oversight over establishment and curricular development of Vocational & Technical Colleges to provincial governments. The construction of this

sector is a significant and important part of the changes in the higher education system of China. Over the last decade the number of higher vocational & technical education institutions grew from about 100 through over 800 (not including 175 post-secondary technical colleges), and the number of students enrolled from 1.17 million to more than 6 million. Two other key factors of interest are that the 5.96 million students enrolled in higher vocational technical schools in 2004 represent 44% of all college students in China (13.33 million), and the 2.37 million of new vocational technical enrolments of 2004 represent 53.1% of all new college recruits (4.46 million) (Zhou, 2006). These trends remained unchanged over the last few years.

In New Zealand, the Tertiary Education Strategy of 2007 emphasizes the need for mission clarification of the different parts of the higher education system, indicating that it has to be achieved through investment policies and implementation (Ministry for Tertiary Education, 2007; Tertiary Education Commission, 2007). While some emphasis is placed on mission differentiation between universities, the mission based contribution of Institutes of Technology and Polytechnics (ITPs) is defined as achieving economic competitiveness via the continuous development of a productive and skilled workforce. The key potential of Technical Institutes and Polytechnics is that, as publicly owned institutions, they can address regional industry support at increasing levels of accomplishment. For comparison, 2004 overall enrolment in ITPs was 191,884 students, in universities and colleges of education 162,322 students, in Wānanga (provide higher education in a Maori cultural context) 69,768, and in Private Training Establishments (PTE) 78,917 students. It means that enrolment in dedicated vocational & technical institutions of higher learning constitutes 39.42% of total enrolment (Education Statistics of New Zealand, 2004). Total enrolment in vocational & technical education may be higher, depending on vocational & technical enrolments in Wānanga and PTE.

In the United States all public research universities, master's universities and colleges have missions that require them to pay attention to workforce development and education within the framework of their course offerings, in part following their heritage as Land-grant institutions, but their university culture, modeled after that of research universities, delivers them less well suited and inclined to make this a major effort. Frequently university industry cooperation is not valued and workforce development needs not reflected in curricula and mode of delivery of education. Associate Colleges, on the other hand, are limited to a two year education that can and does commit to flexible workforce education and workforce development needs, but the depth of education achieved does not always fit knowledge society's need for advanced higher vocational & technical education. This gap may increase due to growing sophistication of products and services.

The task of vocational or technical education at universities and the tension between liberal and vocational education has been with United State colleges since the curricular reforms of the mid-nineteenth century which originated at Brown and Harvard universities (Bastedo, 2005). With the first Morrill Act of 1879 the development of public universities received significant support. Curricular issues were determined by public needs but the tensions between vocational/professional and liberal education were inherited. Lisa R. Latucca writes (Latucca, 2006): "In the late 1800s, as demand for specialization in the United States rose along with more call for practical studies, the emphasis on liberal education in college and university curriculum decreased but did not disappear. Even in the land grant institutions established in the late 1800s, founded with the explicit mission of educating the

citizenry of individual states in agriculture and technical fields, liberal education remained a significant component of higher education." This tension provides even today the basis for important curricular debates.

The public part of the US higher education system in 2005 enrolled about 77% of all college students (13.334 million). In 2005, public Associate Colleges enrolled 6.474 million students, public master's universities enrolled 4.277 million students, and public research universities enrolled 2.583 million students (National Center for Education Statistics, 2006). Associate Colleges as non-baccalaureate institutions train a large fraction of students in vocational & technical areas, but they do not provide higher vocational & technical education. This type of education in the American system is, as derived previously, supposed to be delivered by baccalaureate level and higher institutions. It is, however, difficult to quantitatively assess how many students pursue a higher 'vocational & technical' education without content analysis of bachelor degrees. The overall analysis therefore suggests that there is a need for improved knowledge about higher vocational & technical education for advanced workforce development.

In Germany, 102 universities which include research universities, comprehensive universities and technical universities enrolled in 2004 about 1.38 million students. Only a small fraction of these students is engaged in higher vocational & technical education in applied and professional areas. It is yet to be seen if the changes of the Bologna process bring more vocational & technical education into German universities. Of course, technical universities play a special role. The enrolment in 213 universities of applied science was 0.56 million (Statistisches Bundesamt Deutschland, 2005). This means that about 29% of total formal higher education system enrolment is engaged in higher vocational, technical, and professional education. Absolute and relative engagement and enrolment numbers in universities of applied science indicate that a significant fraction of higher vocational & technical education of Germany's advanced workforce occurs formally outside of the formal higher education system. It indicates that for higher vocational & technical education to be successful does not require it to become a part of a formal/classical higher education system.

5. Role and Development of Higher Vocational/Technical Education

5.1 Current Developments

When goods production and service providing sectors of economies were predominantly resource based, skills based vocational & technical training of a workforce was of importance for success and profitability. Therefore, traditional vocational & technical education was not part of higher education. In many education cultures its location was in compulsory secondary education and its post-schooling position in industrial apprenticeship and related educational environments was very close to the industries in need.

This historical and current proximity to enterprise and economy is an advantage that higher vocational & technical education has and should maintain. It is a strategic asset both for industries and for higher vocational & technical education institutions. One, but by far not the most important reason is, that research and even comprehensive universities missions are frequently centered around general and research education, which creates cultures that are not well prepared to deliver flexible, fast changing curricula, and curricula that can

support the dramatic changes occurring in major sectors of developing and mature economies.

For many traditional industries the material resource base cannot change much (although there are new materials and new knowledge about materials). Knowledge and information will accelerate change in their way of operation in many dimensions, including advancing production technologies and modes, high responsiveness and flexibility in the consumer or demand–supply domain, responses to integrated environmental and workplace safety concerns, or larger issues such as sustainability and in particular global warming and climate change. Workforces will adapt to more complex equipment, production and distribution schemes through higher levels of flexibility obtained through education. Management will require and expect that their advanced demands in compliance and advancement of corporate goals in this complex modern environment will be understood and carried by all employees. As these changes are likely to be continuous and sometimes 'disruptive' with no 'steady state' anywhere in sight, workforce education needs to be providing a good foundation upon which continuous need based and flexible education can be built on. Higher vocational & technical colleges with well defined missions including a forward orientation will be best suited to address this need.

The development of higher vocational & technical education in all countries considered is at a cross roads of development and could alleviate much of the concerns if mission based differentiation of higher education would become one of the arguments. Hence, the development of higher vocational & technical education as a respected part of higher education systems or a respected education trajectory outside of those systems could avoid mission stretch of classical higher education providers.

The vocational & technical colleges in China have had a significant success as demonstrated by the growth in numbers and in enrolment as indicated previously: From 1998 to 2004 the number of vocational/technical colleges grew by more than a factor of eight from 101 to over 872, and enrolment increased by a factor of almost six from 1.17 Million to 5.97 Million students (Zhou, 2006). This constitutes a desirable and significant growth in overall post-secondary education for China, a major outcome of this development is the contribution it has made to the strong growth of goods production in China.

The same drivers for a highly qualified workforce are at work in the United States, especially as production outsourcing is not viewed favorably any more, and opportunities for goods production are considered essential for a balanced economy. The Carl D. Perkins Vocational and Technical Education Act of 1998 (Public Law 105-332, 1998) understands the significance of vocational & technical education and reflects the knowledge based changes, and provides support for pre-baccalaureate programs. Yet for higher vocational & technical education productive sector demands do not have a direct and immediately obvious addressee. Associate Colleges would be the appropriate place for advanced and flexible workforce development, but other than Vocational and Technical Colleges in China, Institutes of Technology and Polytechnics in New Zealand, and Universities of Applied Science in Germany, they are restricted to two year degrees that do not allow them attainment at higher vocational & technical education. There is a strong movement to allow Community Colleges to teach 4-year applied science and technical degrees, and many drivers of economic development would see this as absolutely necessary. But current rules of accreditation agencies, such as the Western Association of Schools and Colleges (WASC) only allow one four year degree per Associate College; otherwise these colleges would have

to comply with the full set of requirements for a university, a condition that would create the typical university attitudes not conducive for higher vocational & technical education. The States of Florida and Texas have created policies to allow Associate Colleges to teach more than one four year degree. So far, predominantly professional degrees are under development. The advancement of Associate Colleges or institutions such as the Tennessee Technology Centers towards the development of three or four year higher vocational & technical programs and degrees could be a key to workforce development through flexible regional industry orientation, desirable in the currently fast changing economic environment.

The role of Institutes of Technology and Polytechnics in New Zealand, through the recent Tertiary Education Strategy (Ministry of Education, 2007), is similarly well defined as that of Vocational & Technical Colleges in China. For the workforce needs of the country they serve a distinct and essential role apart from and in parallel to universities and Industry Training Organizations. Other than higher vocational & technical institutions in China but separate from universities they have the ability to teach three and four year bachelors as well as post-graduate degrees, including the master's degree, in applied technical subjects. This provides Institutes of Technology and Polytechnics an additional dimension of flexibility and prepares them well to knowledge growth and workforce education demands of the future. An additional interesting development occurred in New Zealand in 2001, when the then Auckland Institute of Technology received university status through an act of parliament, to become Auckland University of Technology (AUT). The development of AUT's programs could become a model case for higher vocational & technical education if economy orientation and flexibility in delivery and content prevail.

The attainment of university status of Fachhochschulen as universities of applied sciences is a clear indication of the importance of higher vocational & technical education for the German goods production and services based industries. However, outside of the official higher education system there are many other and diverse institutions that provide higher vocational & technical education. These are positioned even closer to industry and professions, yet with content requirements similar to those of universities of applied science. In general, the developments in Germany in recognizing the increased knowledge, information content, and student attainment in non-university higher vocational & technical education, and its potential recognition through appropriate degrees, provides another approach of accommodating real needs of economic development through practical solutions. Although this German approach has traditional roots it is innovative in creating spaces for recognized higher vocational & technical education outside formal/classical higher education systems. This aspect could have model character and function for countries that want to develop a strong higher vocational & technical education environment without embracing the university as the provider model.

5.2 Transfer and Continuing Education Function

Knowledge in all four macro-economic sectors changes fast and so does knowledge obtained through specialized formal education. By necessity therefore higher vocational & technical institutions in all academic cultures need to focus on being a major resource for lifelong education in their area. The advantage of such institutions is their regional distribution, resulting in close proximity to regional enterprises and their integration with and availability to their communities. This is demonstrated very clearly in the case of

Tennessee where the 27 Tennessee Technology Centers are regionally well distributed, and in Hawaii, where two of the public and all four of the private non-profit universities are concentrated on the by far most populous island, yet public Community Colleges cover five (of a total of six) main islands. Vocational & technical Colleges in China, Institutes of Technology and Polytechnics in New Zealand, and Community Colleges in other US States, also have a wider distribution than universities.

US Associate Colleges in addition to vocational and remedial training of students have the opportunity to engage in a more academically oriented Associate program, for which staff resources and courses are available. During this program students can acquire credit that is directly applicable as transfer credits into Bachelors degree programs at universities. This credit can be gained in courses fulfilling general education requirements and frequently also in discipline oriented courses. Therefore, in Hawaii, students on islands not served by universities can obtain up to two years of university credit before they have to relocate to four year institutions or to distance education modes delivered by four year institutions to complete their bachelor degree education. For periodical retraining and refresher courses in the main subject areas of vocational & technical education, the regional distribution and the engagement with regional economic needs make higher vocational & technical institution a desirable provider of continuous education.

It is obvious that, due to curricular constraints and the lack of higher vocational & technical bachelor degree education, Associate College students that aim at transfer to universities are not likely to be engaged in vocational & technical education. The transfer mission of the community colleges therefore is addressing at present different student populations. However, the concept of 'transparency', i.e. the advancement of talented students from skills based to higher vocational and technical education, from basic diplomas to the most advanced available in vocational & technical education should be given serious consideration as an opportunity for future development. In developing and designing higher vocational & technical education opportunities a student trajectory from skills training to the highest degree of a technical university could be constructed as a means to reach deep into the talent pool for technical innovation.

5.3 Future Developments

Future development of higher vocational & technical education will significantly be influenced by the need for higher levels of knowledge required in all four economic sectors as well as in the field of knowledge itself as a result of knowledge and information potential growth. In addition, there is a unique and growing capacity of enterprises and vocational technical institutions to create new and advanced knowledge outside of the realm of basic and applied research at comprehensive and research universities. Innovation and scholarship in this knowledge and information capability driven vocational & technical environment will have still to be explored, defined and developed in an adaptive process of continuous advancement. But there is no doubt about the capacity as well as need for innovation in the vocational & technical education and research environment. Some theoretical foundations have been provided in 'Scholarship Reconsidered' (Boyer, 1997) though developed on research not specifically addressing higher vocational & technical education. Descriptors and definitions provided include the creation of new intellectual understanding arising from the act of application and the interaction between theory and practice, which both are applicable to higher vocational & technical education. This type of

scholarship has produced new knowledge outside of the realm of university/research institute bound discovery. It can be argued that higher vocational & technical institutions are places where practice based creation of new knowledge and innovation has an opportunity to develop significantly and as the main direction of advanced work of its faculty and students.

The availability of three or four year higher education degrees at Vocational Technical Colleges in China and Institutes of Technology and Polytechnics in New Zealand is taking into account the effects of knowledge growth and information capability growth. The availability of four year degrees and Master's degrees at New Zealand and in German vocational/technical institutions within or outside the official higher education system, providing for the opportunity of higher levels of education in applied and economy related fields, reflects the presence of the scholarship of application as well at the heritage of close cooperation with industries. It also provides incentives for other higher vocational & technical education cultures to consider the establishment of advanced degrees outside of traditional university settings.

6. Conclusion

Higher vocational & technical education has been a major factor for economic advancement of developed and developing countries. Its establishment and growth as a separate part of higher education systems or a separate system is based on its special kind of scholarship and its heritage of being in close connection with economic development. The educational paradigm of higher vocational & technical education provides for larger flexibility and better responsiveness to local and regional industrial needs than the research paradigm of universities. The work of higher vocational & technical education is different in content and direction from that of mainstream universities but has equal requirements in mastering knowledge and scholarship of application.

Knowledge and information potential growth is in the process of transforming the goods production and services sector of all economies either through the knowledge content of products and services, through information technology innovations embedded into products and services, or into production and delivery processes. These advancements will place high demands on the development of higher vocational & technical institutions. As a result and as one opportunity for development, their degree structure will have to respond gradually and with flexibility allowing higher degrees to be developed and awarded under the premise that institutions of higher vocational & technical education are able to maintain industry and community connection through this development process.

The countries compared all show specific strength in their higher vocational & technical education. The clarity of mission and the immensely successful implementation of this segment of the higher education system in China, the flexibility of breadth, depth in level and content, and delivery of the New Zealand Institutes of Technology and Polytechnics and the German higher vocational/technical institutions provide concepts for the further development of higher vocational & technical education as a branch of higher education. The access functionality of American Associate Colleges from distributed entry points via 'transparent' pathways to highest levels of attainment in higher education, provide an important design principle to amplify the impact of higher vocational & technical education development. Altogether, higher vocational & technical education development is an

integral part of the advances all of higher education has to make to address societal needs for the future.

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From 3rd to 5th March 2008 the International Association of Technology, Education and Development organised its International Technology, Education and Development Conference in Valencia, Spain. Over a hundred papers were presented by participants from a great variety of countries. Summarising, this book provides a kaleidoscopic view of work that is done, all over the world in (higher) education, characterised by the key words ‘Education” and ‘Development’. I wish the reader an enlightening experience.

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InTech Europe
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

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Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821

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