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# **The spread of European models of Engineering education: the challenges faced in emerging countries**

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## **Abstract**

The major European models of engineer training (the German, the British and the French model) spread throughout the world during the XX<sup>th</sup> century. Historical heritage, cultural proximity and languages explain the open expression of faithfulness to one system in some countries. In these countries, the national standards inherited are now completed by international standards or are in direct competition with new influences. This article will attempt, through existing literature, interviews and on-site investigations, to analyze current engineer training in some emerging countries and its relations with European models, the objective being to analyze the evolution of local systems and so the challenges and issues raised by the dissemination of European models.

Keywords: Training model; internationalization; Morocco; Algeria; Mongolia; Vietnam

## **1. Introduction**

The major European models of engineer training spread throughout the world during the XX<sup>th</sup> century. In different countries, the three dominant models (the German, the British

and the French model) have been adopted. Historical heritage, cultural proximity and languages explain the open expression of faithfulness to one system in some countries. Nowadays, in these countries, the system inherited is transformed by international standards or is often in competition with new influences.

How have the educational institutions adopted foreign training models and how have they updated these ancient or more recent systems? How have the different engineering trainings interacted between adaptation to globalization and preservation of national features? Why and how have the universities adopted new models in the conception of their curricula? For what purposes and on what conditions? How are the norms of these models adopted, adapted, completed? In this paper, we propose to focus on the example of 4 emerging countries: 2 in North Africa (Algeria and Morocco), and 2 in Asia (Mongolia and Vietnam). In North Africa, we can observe the evolution of the French model in the context of globalization which leads us to suppose that higher educational institutions around the world have been remodeled by multiple influences. In Mongolia and in Vietnam, where there are many influences, it is interesting to see how these models are transformed and how choices are made in a very competitive environment. We will attempt, through existing literature, interviews and on-site investigations, to analyze current engineer training in these countries and its relations with European models at the time of internationalization of higher education (Section 2), the objective being to analyze the evolution of the models in the context of their exportation (Section 3) and thus the challenges and issues raised by the evolution of local models between the norms of internationalization and the will to retain national characteristics (Section 4).

## **2. Internationalization, standardization and competition in both Northern and Southern countries**

In order to make the European Union “the most competitive knowledge economy in the world by 2014”, the Lisbon Strategy was defined in 2000 and as such was in direct line with the Bologna Process set up officially in 1999. The objective of creating a common area of higher education and the procedures governing it (the “LMD” or “graduate, post-graduate and doctorate” system) spread beyond the borders of Europe, and the process took on international proportions. There was great upheaval in many countries. Thus, Turkey joined the system in 2001, Russia in 2003, and the Caucasus in 2005 (Armenia, Georgia and Azerbaijan). In Africa, Morocco adopted the LMD system in 2003, the CAMES (The African and Malagasy Council for Higher Education) in 2005, followed by Algeria and Tunisia in 2006. Some see this enthusiasm as a sign that the Process was considered to be an essential, international reform (Lebeau 2006) and a normative set of measures to be implemented. As it has developed, this “higher education area”, at the heart of which lies certification frameworks created to harmonize systems of different origins – the first of its kind in the world – has attracted global attention, even of countries as far away as Australia (In South-East Asia and South America other initiatives have also seen the light of day).

The Bologna Process led and has led to several concrete realities and raises some major issues: standardization, competition and, for each European country, the need to preserve specificities in a competitive context. A certain standardization occurs in the organization of the establishments (founded on equivalence and internationalization) and competition materializes in the form of the quest for attractiveness to students (Augusti 2007).

Emerging countries are just as concerned by the opening up to competition in higher education. In fact, the area of competition is global, where the universities of the great Asian cities (Singapore, Hong Kong, Shanghai, Bangalore) are equally places of

excellence, and where countries such as Morocco enter the scene as countries recognized for the quality of their higher education (state and private institutions, international universities, branches of foreign engineering institutes, etc.). The higher education establishments try to be attractive to foreign students by underlining appealing characteristics. International activities also seem to be the leading preoccupation today in certain establishments, in particular Anglo-Saxon universities (OECD 2011). Although more than 4 million students are internationally mobile today, statistics predict a figure of 5.8 million in 2020 and 8 million in 2025 (Campus France 2014) and the figures show that African students are the most mobile students in the world: according to UNESCO figures in 2009, 1 African student in 16 frequents a foreign university, compared to 1 French student in 29 and 1 American student in 250. South-South mobility is growing (Mazzella 2009), which contradicts a strictly hierarchical point of view. The most attractive countries are not always those we expect, the map of small and large centers of the higher education world market have become more complex and nothing is immutable as demonstrated by Börjesson et al (2011). For example, we could quote the slight reduction in the drawing power of Germany and the United States since 2009, and the increase in the number of foreign students in Morocco, South Africa and Malaysia (Campus France 2013).

Similarly, the idea of a global, fluid market, accessible to all and where supply and demand are in harmony should be revised. Tough academic and consular selection procedures and the capacity to shoulder the financial burden of studies bring the freedom of movement of students into perspective. Faced with these restrictions, the southern more accessible countries are the favored targets for the “education merchants” (Laval and Weber 2006) in the context of privatization of the higher education sector.

Most of the emerging countries are also concerned by the estimation of the knowledge economy and its imperatives and the training of engineers is at the heart of these challenges. Concerning engineering training, these countries try to position themselves. The national policies, the stakeholders and the relations between the States relate to each other are redefined in this competitive context. The northern countries make attempts to maintain their specificities through the exportation of their engineering education models. As we have just seen, we must detach ourselves from a peripheral-central vision in order to analyze this situation.

We propose here to analyze the influence that engineering training undergoes in four emerging countries. Thanks to all the contributions in this special issue, we have seen the differences between the three major European engineering training models. The French is based on very selective « grandes écoles », where the more theoretical the training, the more it is elitist. In France, there are nearly 200 small and specialized institutions which have historically mostly developed outside universities (see Lemaître, in this Journal). German universities are very open to companies, focused on the demands of industry (see Morace et al. in this Journal). Engineering students have much practical experiences and do systematic experiments during their studies (Jørgensen 2007). There is also a strong link between research and teaching, as a heritage from Karl Wilhelm von Humboldt who maintained that an institution without research cannot be defined as a university (Augusti 2007)

The British model is very dependent on Professional Bodies which is very prescriptive. Each Professional Body creates its own accreditation system. Programs are accredited based on the discipline system even if there is an overarching body, the Engineering Council, whose framework guides the individual Professional Body

systems (see Kloot and Rouvrais, about the British model implemented in South Africa, in this Journal).

These models spread throughout the world during the XX<sup>th</sup> century: the British model in India and in the other countries of the British Empire, the German in Russia and in some countries of Asia... Due to the French colonial expansion during this period, the French model of engineer training constituted until recently a reference model for many countries in the formulation of their curricula especially in French-speaking Africa. It would be interesting to see if nowadays this model still constitutes a reference in these countries and if that is the case, what are the current forms of its legitimization. What about the other important European systems? What happens when a particular country relies on several of these models for the formulation of its training programs? Does one dominate the others or do they combine to create a new form of legitimization, a hybrid of some sort? These were the questions that a multi-site survey, conducted in 2015, attempted to answer.

### **3. The curricula transformations in four emerging countries**

The results concerning four countries will be presented in an attempt to answer the previous questions. The survey was carried out in several countries<sup>1</sup> with the aim of collecting information, points of view and the stance taken by the different stakeholders as to current engineering education and its evolution. Semi-structured interviews have been conducted with deans of studies, deans of faculties, lecturers, and also with industrials who recruit engineers. Researchers have analysed the content of what the

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<sup>1</sup> Field studies were carried in these countries by researchers from ENSTA Bretagne with the collaboration of local colleagues: Mohamed Benguerna in Algeria, Bin Dao Quang, My Le Thi, Vinh Nguyen Quang, Tam Tran Dan and Dai Nguyen Tan in Vietnam. In Mongolia the survey has been conducted by Boldmaa Naran and Altangul Bolat.

protagonists have to say about questions of current engineer training in their country and their representation of innovation. The approach is one of sociological study of the curriculum as we are interested in the study programs not only through the pedagogical measures put in place, but also the selection, structuring and knowledge transmission processes (Forquin 1996, 2008).

### ***3.1 Algeria: a training system (not openly) based on the French model***

In Algeria, as we will see in Morocco, engineering schools, built on the pattern of the French model of “Grandes écoles” are reserved for the “happy few” who become the State elite. In Algeria, the higher education system had been historically based on the French system and remained closely linked through cooperation agreements. But it was also built with the support of USSR in the 1960’ and 1970’, and to a lesser extent with the American support, and has kept the influence of these models (Kadri 2015). Engineering training in Algeria kept the heritage of these different systems, with “grandes écoles” based on French model and faculties of engineering in universities.

The higher education system, for political reasons, was not developed along exactly the same lines as the French model. With, on the one hand, the elite trained in France and faithful to this system, and on the other, the political desire for “Arabization”, Algeria maintained a French educational framework without applying the developments that saw the light in France. The replacement of French by Arabic in education and the non-adherence to La Francophonie (despite the fact that Algeria is the third country in the world in terms of number of French speakers, behind France and the Democratic Republic of Congo) show the reluctance of Algeria to remain strictly faithful to the legacy of the former colonial power. Thus, the pupils have their classes in Arabic until the Baccalaureat. French is the language of higher education for scientific and technical



subjects and the training is in French in engineering schools.

While, on a political level, discussions are chilly, in Algerian engineering schools, the French context of engineer training and the pedagogical developments implemented in French schools are all too apparent, as is the development of academic partnerships with French establishments. The heads of engineering schools (directors, heads of training...) paid particular attention to the recommendations of the French Commission des Titres d'Ingénieurs (CTI). Created in France in 1934 by the Law establishing the protection of the title of engineer, the main purpose of this commission is to issue recommendations for engineering training and to accredit higher education establishments to deliver engineering diplomas<sup>2</sup>. To begin with, the CTI was purely intended for French training whereas today this role has extended to an international accrediting agency upon the request of foreign establishments. This is revelatory of the influence of the French model of engineering education beyond its borders.

Based on an elitist approach which aims to satisfy the needs of the State, engineer training in establishments such as the Ecole Polytechnique d'Alger leads, just like in France, to prestigious positions. Simultaneously, other engineers are trained at science and technical faculties in the universities. Some of these faculties are the results of institutes and schools inspired by the Russians or the Americans in the 1970s (Kadri 2015, Benguerna 2004) which were reintegrated later to universities and so have lost their specificities.

Within the Bologna Process, Algeria has embarked on reforming the management of universities (Law on the Orientation of Higher Education of the 17

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<sup>2</sup> [www.cti-commission.fr](http://www.cti-commission.fr)

August 1998 and its enforcement by the Executive Decree of 23 August 2003). The reform of higher education was adopted by the Ministerial Council of 30 April 2002. The implementation of the Bologna Process in Algeria is regarded by the university to be a “catastrophe”, at least by the lecturers met during the survey. The loss of hours (“We have lost 4000 teaching hours since the reform” said one teacher in a technical stream of the University of Boumerdes) has had a major impact on the quality of the training, whereas the most pedagogically promising aspects of the system are deceptive due to the difficulty in applying them (project work, internships in companies, etc.). According to the university lecturers interviewed, accompanying students encouraged to work autonomously on projects is not easy in the age of the internet and search engines, when the teachers have not been trained in these new technologies. Moreover, the training establishments aim to impart precise professional skills so that the curricula are rigidly drawn up and there is no modularity possible or freedom to choose from options for the students whereas modularity is one of the strengths of the LMD system.

By changing to the LMD system, the universities which previously delivered an engineering diploma to accompany studies in science and technology are no longer authorized to deliver this title. The graduate schools have also embarked on the LMD system, but not completely and they continue to deliver the title of Engineer, as in France. Even if they still remain on the French model, they were not developed along exactly the same lines as the French model (deepening of relations with companies, development of human training...). The survey conducted showed that Algeria, which kept the French model that some qualify as “Napoleonic” (Laurini 2013) has difficulties in modifying it in accordance with all the requirements. That is why, for example, there are still engineer courses on textiles although the textile industry has collapsed in Algeria and every year the number of unemployed increases.

Nowadays, there are no real influences from other countries because of the lack of openness in the education system. Private schools of higher education have appeared but they are confronted with the problem of status and recognition of the diplomas awarded. Furthermore, access for foreign training institutions is closed, which blocks the competition between institutions and the transformation of the higher education landscape. There is a growing gap between this elite training and the universities. Moreover, leading educational institution graduate migration is extremely high (between 60 and 100% of graduates of the National Polytechnic School of Algiers move to foreign countries immediately after they graduate, depending on the year and the specialty, said one of the deans of study we have met). In fact Algeria does not profit from these highly skilled expatriate human resources, contrary to Morocco which tries to do so (Cardona Gil et al. 2016).

### ***3.2 Morocco: faithful but not dependent***

Like in Algeria, the training in Morocco, which was delivered with a pragmatism aiming to satisfy the sector-specific requirements of the State departments, is delivered by the engineering schools based on French model, which multiplied in the 1970s. Employment, quasi automatic upon graduating, explains the enthusiasm for this path to high achievement, which enables privileged study conditions, immediate employment and high social mobility rolled into one, guaranteeing access to the civil service and positions of prestige (Mellakh 2011). As for France, the « massification » seen by the universities in the 1980s, with its consequences (financial crisis, unemployment of graduates) (Mellakh 2006) reinforced the elitism of engineer training. On one hand, engineering schools were reserved for the “happy few” and on the other hand, the “dumping-ground universities” trained the masses (Vermeren 2005). Although

the numbers attending French model based engineering schools did greatly increase, we will see that this system is open to letting institutions based on other models settle in the higher education landscape.

There are a large number of schools (about 20) delivering engineering diplomas. Based on the French model, some of these schools are members of the French CGE (Conférence des Grandes Ecoles)<sup>3</sup>, such as the Institut National des Postes et Télécommunications (INPT) or the Ecole Hassania des Travaux Publics (EHTP) and are preparing their accreditation by the French Commission des Titres d'Ingénieurs (CTI). The directors of the schools interviewed during the survey explained that they paid particular attention to the recommendations of the CTI and their recognition by the CGE. There are 165 engineering schools in the CGE, 156 of which are French and 9 from other countries. Of these 9 foreign schools, 3 are from Morocco, which shows the proximity of the Moroccan system to the French one. There are numerous exchanges with French schools in terms of partnerships, enabling not only the mobility of students but also common research projects and discussions on important questions, especially on pedagogy. There is an open expression of faithfulness to the French system, especially on the part of school directors, training managers and academic staff who, speaking perfect French, have mostly carried out part of their studies in France. On a top level of the State, the proximity with France is explained by the training in France of the political elite: a large number of ministers, royal advisors, governors, heads of Moroccan offices trained in France, especially at the Parisian Ecole des Ponts et Chaussées. The elite in Morocco, as in Algeria, remain largely French-speaking and

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<sup>3</sup> The “Conférence des Grandes Ecoles” is a non-profit association of engineering schools, management schools and higher education institutions offering other specialities. The CGE accredits its members' educational programmes (post-master Master's, MSc, BADGE) both in France and abroad.

even if efforts have been made by certain families to broaden the linguistic skills of their children, there is a very high correlation between social and professional success and mastery of the French language (Vermeren 2005). In addition, there are branches of French schools such as the ESIEA, ENSAM or the Ecole Centrale de Casablanca which is being created.

However, the interest for the French model is not exclusive. Engineer training is considered as highly strategic for Morocco, which relies on industrial development and the knowledge economy. There are many initiatives, from teachers, from heads of trainings, and from the upper echelons to think and to act for the qualitative and quantitative development of engineer training, searching for inspiration from around the world. The standards delivered by the French CTI are sometimes completed by European standards, through the label EUR-ACE (The EUROpean ACRedited Engineer).

Nowadays, the interest in international standards such as the CDIO<sup>4</sup> or the accreditation by the American agency for accreditation (ABET) is growing even if so far there is no CDIO member in Morocco and only one Moroccan training program officially certificated by ABET: Al Akhwayn University Bachelor of Science in Computer Science. Founded in 1993 by a Royal decree, Al Akhwayn University in Ifrane has modeled its administrative, pedagogical, and academic organization on the American university system, and English is the language of instruction.

There are also a certain number of private schools in Morocco which trains engineers. Even if France has played a major role at the fore front, it is not the only

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<sup>4</sup> Created at the end of the 1990s under the impetus of American and Swedish lecturers, the CDIO is a collaborative, international initiative of reflection and improvement of engineer training. It comprises about fifty universities in the world which have adopted this initiative. Based on an approach judging competence, the CDIO framework has based its engineer training objectives on the real life activities of engineers in the world of work (Conceive, Design, Implement, Operate).

partner, partnerships also having been established for future projects in Morocco with Spanish (Universitat Politècnica de Catalunya /Polytechnic University of Catalonia), Italian (Politecnico di Torino /Polytechnic University of Turin) and Russian universities (14 Russian universities have merged to create the Grande Université de Casablanca).

All of this makes the Moroccan landscape of engineering education very dynamic. Although there are some difficulties such as discussions between the academic and industrial worlds which still fall short due to their fragility and novelty, the will to remedy this is there. The heads of training organizations interviewed (deans of studies, school directors) and the teachers seem to be aware of the criticisms and raised by the companies (the need to develop the students' non-technological skills, their knowledge of the professional world, team work via projects), even if the impediments remain: sometimes a lack of ideas on how to achieve objectives, sometimes reluctance to replace technical hours by hours of non-technical subjects, sometimes the frosty reception of the teaching team when faced with the change in pedagogical methods, often inefficient coordination or lack of finance. On the whole however, in the climate of emulation and economic development that Morocco is experiencing, the will to adapt to company expectations predominates, inspired for a large part by the goings-on abroad and the recommendations of the French CTI.

The favorable political context which is open and even willing to invest in the quality of engineer training and, above all, innovation, enables training organizations to be masters of the development of their own curricula. Even if a few weaknesses hold back the perfect implementation of these policies, the advance is rapid and perceived as stimulating by the different stakeholders interviewed. The project to develop an Economy Based on Knowledge is materializing through a multitude of large programs, all aimed not just at national development, but also at international awareness, in

particular towards Africa. Engineer training is central to these ambitious projects and is identified as such at all levels and by all the stakeholders, and the means have been invested to improve current conditions and develop quantitatively and qualitatively.

Even if the engineering training is good and dynamic in Morocco, France is considered as being a logical destination and as a regal path for Moroccan students on their way to becoming engineers. Thus, 3000 Moroccans are received in French engineering schools each year, which represents the greatest number of foreign students behind Chinese students (CGE, 2011). It is not unusual to hear students or parents who say that to become engineers the best way is to study in France, and to have a career in business it is better to study in Germany or in Great-Britain.

Finally, the higher education systems in Algeria and Morocco are still close to the French system, due to cultural, geographic and linguistic proximity, but there is a commitment to openness, especially in Morocco. The French model is also relevant in other countries, such as Vietnam, even if their dedication is less.

### ***3.3 The training of engineers in Vietnam: an open market***

Industrial development in Vietnam, embarked upon in its current form since the liberalization of the economy in 1986, has led the government to pay particular attention to higher professional education. At a crossroads of multiple, historical influences (Confucian, French, American, Soviet) and committed to diverse international cooperation agreements, the training institutions have varied and competing reference models. Engineer training must provide efficient agents in industrial and agricultural development and even in the construction of new infrastructures. To satisfy these requirements, certain universities have developed elitist training labeled as excellent,

breaking with academic tradition, and taking their inspiration from other countries. It is these new engineer training streams which we have observed in Vietnam.

The liberalization of the economy in 1986 profoundly modified the higher education system in Vietnam. It was mostly inspired until then by the Soviet model, characterized by technical institutes with a very theoretical and fundamental teaching (due to the influence of the French engineering school in the XIX<sup>th</sup> and to the social composition of engineering students since the time of tsarist Russia, who are from the nobility and denigrate practical work) whereas the practical and applied training assigned to the industry, outside the university (Kotlyarov et al. 2015). Training rapidly went from state run to a free market which left room for private initiative. In this context, many higher education establishments have seen the light of day. Their number quadrupled between 1998 and 2013, from 123 to 427 and the number is still rising. As for the students, there are more than two million today, their number having multiplied by 20 over the last 20 years. This shows how exponentially the number of higher education graduates has also increased, among them a minority of engineers, trained in technological universities.

There are three types of training course that enable this status to be obtained : ordinary engineer training where the curricula depend directly on the criteria defined by the Ministry for Education; engineer training at the two national universities of Hanoi and Ho Chi Minh City; a stream for high achievers based on international partnerships. If their training policies are different, they are just as distinctive when it comes to the education models proposed to their students (Cardona Gil and Lemaître 2017). The influences of the Soviet model, and to a lesser extent the Confucian model, remain significant in classical training. Their Confucian heritage is underlined by training institutions in Vietnam, as many others in East Asia, claiming traditional and practices



attitudes derived from the teachings of Chinese philosopher Confucius and his followers: emphasis on ethics and statecraft, merit bases system, education be seen as the route to social status. The features of this system are also a relatively close national supervision and control and the “one chance” examination system at the end of schooling (Marginson 2011). However today engineering trainings are under great competition from the French and American models, especially within the framework of competitive selection. With training bodies opening up to world markets as a direct consequence of liberalization, the result has been more and more engineer training on the basis of international standards.

The Vietnamese Ministry of Education and Training has decided on 2007 that programs have to be audited and accredited based on criteria established by the Association of Southeast Asian Nations (ASEAN) University Network (AUN) or by an international accreditation organization. This has set the stage for the competitive accreditation of engineering trainings (Le and Nguyen, 2009). The American ABET was particularly active to promote its label in Vietnam. Since 2006, ABET, with the support of Boeing Company, has organized a series of events in Vietnamese universities to promote ABET accredited programs and to support educational institutions which want to create an action plan for future implementation of the ABET criteria (Ibid.).

From the point of view of companies, they manage to recruit, thanks to the new training courses, a new type of engineer who is more capable of managing potentially innovative projects. If they are campaigning for closer ties between schools and companies, the head of companies met do not believe the legacy from the French system is a handicap to “satisfying the demands of industry”. However, they sing the praises of the American system which, through using student-led learning and

encouraging discussion, gives them “the opportunity to express their thoughts”, which enables them to reinforce their reflective skills.

The internationalization of higher education has profoundly modified the strategies of establishments (Leclerc-Olive et al. 2011). Pushed into reorganizing their training programs around the productivity principles dominating the current higher education market means that they have become, as others before them, real “firms” in competition with each other within an open market (Lemaître 2015). The partnerships which exist between the high achiever streams and abroad do, however, lead us to question the recognition of Vietnamese engineering diplomas, as well as the viability of a system which will, without doubt, evolve in the next few years, due to the opening up of the country and the internationalization of its training programs, as well as the inequalities that this is likely to engender. The training of Vietnam’s managerial elite, in full development, is leaning more and more towards the adoption of Anglo-Saxon models for the composition of its training programs. Similar to observations elsewhere in South West Asia, the exogenous and heterogeneous nature of the training has generated many debates as to its suitability for the local economic environment (Broustail and Palaoro 2005). Although most of the training programs last four and a half years or even sometimes five, the diplomas that they deliver are not recognized by the Vietnamese State at a Masters level (but at a Bachelors level, or 4 years post high school certificate), whereas some high achiever programs are authorized by the French CTI to deliver the title of engineer, and thus have a Master level. The will of certain deans of studies to harmonize their 5 year training programs and the Resolution of May 2015 to obtain the grade of Master for PFIEV graduates let one suppose that engineering training is, in a way, better abroad than at home. Thus, to solve the problem, some students do not hesitate in going abroad to train to obtain a Master or a

Doctorate. This relatively recent phenomenon concerns many engineering students, who often subsequently embrace an international career, which does not fail to generate debate in the media. Thus, the majority of Vietnamese engineers train and are recruited locally, to answer local needs in sectors which have sometimes fallen behind in international affairs. Thus, one of the current directives is to train 20 000 doctors in the next ten years, which shows that international standards are creeping into Vietnam, creating a sort of two tier system, between a cheap, Soviet legacy system with training geared towards things technological for engineers destined to remain in the country, and the “internationalized” system, which is much more selective and bears many inequalities (commodification of higher education and international career paths).

An important question is that of the access to this training when the social opening of these schools has currently transformed into a jostling for position (Buisson-Fenet and Draelants 2010). In some ways, the creation of these streams of excellence has reproduced the types of selection and hierarchization observed for so long in the European and American training systems. The French graduate schools or the great American universities are places for reproducing the elite, according to well-recognized processes. The goal is to select a group of students, placed in a privileged environment and destined to become the ruling elite in companies and administration, which does not fail to raise controversy. This type of conflict and debate, between democratization and the training of the elite are observable in another Asian country which is the object of our attention, Mongolia.

### ***3.4 Mongolia: on a quest for openness to the world***

In Mongolia, engineer training started in 1950 during the implementation of Soviet industrialization policies. In an extremely rural country, where the traditional economy

has been nomadic pastoralism, the main areas of training and activity are energy and the food industry. Urbanization and the development of industry, in particular between 1970 and 1980, would require the training of engineers capable of driving these changes. In 1990, Mongolia left the socialist regime to become a free market and social, political and economic life underwent a radical change. Mongolia opened up on an economic as well as a cultural and political level. Today, Mongolia is determined to listen to what is going on in the world, whilst developing its own distinctive characteristics: pastoral nomadism and until now, its partially unexploited mineral resources.

Technician and engineer training was ensured with the help of the USSR and other socialist countries which provided the teachers in the training establishments, and organized training internships and evening classes through their collaborators on the ground. At the beginning of the 1960s, although the country had progressed in light industry and the food industry, heavy industry had not developed relations with the USSR and other socialist countries being so close, the leaders considered that these sectors could be replaced by the skills of “brother countries”. Little by little, the need to reinforce industrial organization, its mechanization, the construction process of buildings and motorways, required the local training of Mongolian executives. The Faculty of Civil and Industrial Engineering, Energy and Geology was founded with this objective in mind in 1959 at the National University of Mongolia. In 1962 the Faculties of Light Industry and Mechanical Engineering were created. Departments of civil engineering architecture and energy were also set up. That same year, the Polytechnic Institute was created within the National University, which subsequently became the University of Science and Technology in 1990. Almost 80% of Mongolia’s engineers would graduate from this structure. The State University of Agriculture was created in

1960. It would also prove to be a pillar of engineer training. As in the soviet model, until 1990, great importance was given to factory internships, which were to enable students to enhance their technical knowledge and discover the organization, management and use of equipment.

Today, engineer training is ensured by public universities (the National University of Mongolia, the Mongolian University of Science and Technology and the Mongolian State University of Agriculture), by public institutes (the Mongolian Railway College, the Institute of Botany and Agricultural Research and the very new German-Mongolian Institute for Resources and Technology), a private institute (the New Mongol Technique and Engineering College) and through branches of Russian universities (branches of the East Siberian State Technological University, a subsidiary of the Irkutsk State University). Most engineers are trained according to a training model which is close to the bases of the German and Russian systems, but which has evolved differently as today company internships are few for student engineers. This is explained by economic reasons and also a deep political and economic upheaval experienced in 1990, following which there was mass closure of state companies. Similarly, due to a lack of funds, research is little developed and engineer training is carried out in a way that is detached from research.

There is a great need for highly skilled engineers. The mining of gold and copper at Oyu Tolgoi is a colossal project for the country. Its implementation required an initial investment of 4.6 billion dollars and its production is expected to represent 30% of the country's GDP in 2020. Mining started in January 2013. In the heart of the Gobi Desert, where towns are non-existent and the climate is extremely arid and hostile, with an annual temperature range of -45°C in winter, to +45°C in summer, and where there are no roads, Oyu Tolgoi represents the greatest technical, human and

environmental challenge Mongolia has ever seen: ultra-efficient mining infrastructure, high output mineral processing facilities and all the accommodation and services necessary for 10 000 employees. 60% of these employees, mostly engineers and executives, are foreign. This represents a certain number of challenges for Mongolia: having enough resources to succeed in such projects (geological prospection, mostly “rare earths”, extraction etc.), working towards increasing the value of these minerals by developing industries (raw material is currently sent directly to China), facilitating transport of resources and developing extraction methods which are respectful of the environment. Improving the judicial and financial environment of higher education, developing human resources, improving teaching and research standards (from “adapting to social demand”, to “technological progress” and “meeting international standards”), supporting a “national conscience”, increasing the number of students in engineering, medicine, natural sciences and agriculture...all these are projects making up the Mongolian Higher Education and Research Reform Project 2021 (Хөрөнгөоруулалт, өргөтгөл, шинэчлэлхийхсалбарынжагсаалт 2021).

According to the Mongolian Government, the need for engineers is high, not only for mining but also for industry, agriculture, infrastructure, health, energy, light industry, the food industry or telecommunications. Thus, discussions stress the training of national engineers, the construction of laboratories and the development of research favoring links between companies and universities. Although discussions are very present at a political level, the realities in the field are far from the defined objectives. The Mongolian university system particularly suffered from cuts to its budget and the departure of foreign experts at the moment when Mongolia was no longer under Soviet umbrella. The large number of private higher education establishments led to competition in both the recruitment of students and quality staff. With spending on

university research at just 2.7% of the budget, management of university institutions which has not been renewed and low salaries for professors and lecturers, the Mongolian universities are struggling to reach their targets. Investment in the construction of classrooms, building maintenance, the improvement of research laboratories, the development of communication tools and the modernization of multimedia libraries are all cruelly lacking<sup>5</sup>.

Education is announced as a priority for the Mongolian Government at a time when the country is banking on an economy based on knowledge to develop and ensure intelligent transformation in response to urbanization and extraction of mineral resources as well as the changes brought about by great technological and above all environmental and social challenges. The training of engineers capable of facing up to such challenges is experiencing great difficulties. The lack of adequate human resources, the lack of budget and the climate of corruption demonstrates that the reality experienced by the universities is quite different from the ideals announced by the programs, projects and speeches of the political heads.

However, the powers-that-be as much as the Mongolian citizens in their own way, are not neglecting to observe the developments occurring in other countries, and using them as an example, whilst aware of their differences and the strong points that they can enhance. The government is counting heavily upon the student diaspora and is thus encouraging student mobility to foreign universities, hence the development of international partnerships and the establishment of foreign training establishments in Mongolia. A project has been on the cards for the past few years to send engineers and technicians to be trained in developed countries. It was brought to fruition in February

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<sup>5</sup> <http://www.meds.gov.mn/>

2015, when Parliament adopted the “Higher Education Training of Engineers and Technicians in Japan” project. In summary, Mongolia is open to developing its training systems, and is not tied to one model in particular. Open to the experience, Mongolia means to face the challenges it is confronted with, in a context fraught with difficulties, but in which the training of engineers plays the central role.

After the remainder of these four examples in North-Africa and in Asia, we will see what the transformations in engineering education concretely show in these countries.

#### **4. From a norm for development to the will to retain national characteristics**

The reasons for adaptation to international standards and above all, the objectives pursued, differ quite widely from one country to another, among those who seize it as an opportunity to develop the quality of higher education, or the economy of their country, those who view it as a constraint (a necessary step) and those who attempt, despite everything, to retain national characteristics, adapting a foreign model with national characteristics. In all of these different cases, the evolution of imported European models over a longer or shorter period will be different. It should also be noted that the governments do not have absolute control over the developments taking place in their country.

The institutions’ heads generally attempt to adapt to local needs, be they pertaining to society or industry. Yet these priorities differ from one country to another and are sometimes discrepant: feed populations, build roads or infrastructure on one hand, develop new technologies on the other, be attractive for students (domestic students or foreign students from other Southern countries, such as Morocco which welcome foreign students from other African countries). Thus, the objectives assigned to this training can also be wide-ranging (ensure the economic and/or industrial



development of the country, encourage the extraction of natural resources through the use of new technologies, provide technical executives for the country, innovate to acquire or consolidate a dominant position in an international context, train its elite, etc.), just as much as the fields of activity for which the engineers are destined.

Until recently, it was often the case that institutions in a same country followed a single training model, mainly for historical reasons (the existence of specific cooperation measures between France and the Maghreb countries, the Russian or German influence on the East, etc.) This observation is in agreement with the distinction made by Raymond Aron (1984) between “international society” and the “interstate system” taken up by Sylvie Mazzella (2009) to explain that “if there undeniably exists an international dimension in the transformations which affect the educational systems in southern countries, they cannot be put down to merely this horizon of a global society or even to the autonomized history of each of the States studied but find their meaning in the relations between the States”. There are several centers of attraction which correspond to historical developments. Whereas India is the 2<sup>nd</sup> exporter of students after China, they are almost not to be seen in France. Similarly, until now, students from former French colonies have more naturally turned towards France. The OECD, in a document published in 2011, predicts the development of cross-border partnerships in higher education according to linguistic, strategic and even religious affinities (OECD 2011).

Most of the countries do not hesitate to base themselves on several models, such as Mongolia (Russian and German models) or Vietnam (Confucian, Soviet, American and French influences). On this point, the encouragement of the Mongolian Government to develop international partnerships and the establishment of foreign training establishments on its territory is certainly not a million miles away, as is the growing

image of autonomy of the universities of Vietnam which are trying to “carve out a place” in a globalized training market. It leads in many places to a two-tier system where a minority of engineering students receive high quality training in elite institutions while the majority receives low quality training in non-elite institutions. According to some authors, although this two-tier system exists in developed countries, it is above all a characteristic of BRIC countries (Loyalka et al. 2014).

Similarly, the countries whose training models have been imposed for a long time, do not always have a clear strategy to maintain their influence abroad. If we take the example of France, we are witnessing the closure of French cultural centers especially in French-speaking Africa, policies discouraging emigration and, as far as engineer training is concerned, little effort in encouraging African students. There is also an absence of policies advertising the French model of engineer training in Africa, whereas most training establishments in French-speaking Africa have been built on the French model. Paradoxically, at a time when the African continent is undergoing demographic increase, economic increase and the emergence, even if in the early stages, of a middle class, France is turning her back on this continent with which she has held privileged relations for historic and cultural reasons.

Since the 1980s, the accreditation engineering models are affected by the globalization. The accreditation by a foreign agency is significant for engineering training institutions in many countries. It is viewed as the recognition of the quality of the training. Indeed accreditations agencies play an increasingly important role in the improvement of engineering training quality in emerging countries as they have played a crucial role in monitoring the quality of trainings in developed countries (Loyalka et al. 2014). Accreditation also means a better national and international visibility for the institutions as for the students. We have seen in our survey that the accreditation of

programs by the French CTI will attract foreign students who may not have otherwise had the financial or administrative (obtaining a visa) means of coming to France. It is the case of the French-speaking technical faculty of Sofia in Bulgaria for example, accredited by the CTI, and which receives a large number of African students, thus reinforcing its position in the rankings.

If the accreditation of the CTI seems to constitute a means of recognition of the French training system, other countries are more active in their search for a ranking for their system, demonstrated by the United States which try to pull African and Asian engineering schools into their wake.

The United States has been engaged in the establishments and propagation of engineering accreditation all around the world. Through its accreditation policy, ABET (Accreditation Board to Engineering Training) promotes an influential American way to conduce engineering training, especially in Asia (Mohd Said et al. 2013). Many international agreements have been established, as the Washington Accord in 1989 (signed by the USA, Australia, Canada, the UK, Ireland and New Zealand), on the base of multiple criteria of quality, and with the objective to ensure a high quality level in the trainings and a substantial equivalence of accreditation systems of various organizations and engineering education programs in the signatory countries. Furthermore, this accord allows an engineer graduated for a signatory country to work in another Washington Accord member country. After that, similar accords have been set up, such as Sydney Accord in 2001, the Dublin Accord in 2002 and EUR-ACE in 2005 (Patil and Codner 2007).

For countries which were not in our panel and so where surveys have not been conducted, we can see, thanks to the literature, that they are inspired by accreditation criteria from many countries, and do not show allegiance in one unique model. For

example, it is the case in South-East Asian countries where engineering trainings are inspired by the accreditation criteria from the United States (ABET), from Japan (JABEE), from Korea (ABEEK), from Canada (Canadian Engineering Accreditation Board), from China (CAST) and from Hong Kong (Hong Kong Institutions of Engineers).

Thus, many accreditation agencies are competing to influence engineering trainings around the world. If the American ABET is very influential, the French CTI remains significant especially in countries where historical relations with France were strong in the past, or where the French language is yet used in higher education. The lower visibility of other European models could be understood viewing the historical development of their accreditation system. Indeed, the word “accreditation” was used in the United States since 1930s (Augusti 2009). On the European continent, formal accreditation was started in France when the 1934 Law established the CTI whereas in the United-Kingdom programs are accredited by discipline by professional bodies (under the supervision since recently by the UK Engineering Council). In Germany, the programs must be in strict conformity with State or Federal rules, which given to accreditation like ASIIN a limited significance (and ASIIN is often bad considered by universities which do not accept this top down supervision).

In Russia, the Russian AEER (Association for Engineering Education in Russia) takes also a more active part in the accreditation landscape. It has recently signed the Washington Accords, the Asia Pacific Economic Cooperation (APEC) Engineer agreement, and is a member of the EUR-ACE network and accredits programs, even if up to now it was restricted in geographical terms (Russia and ex-USSR Central-Asian republics) (Pokholkov et al. 2004). Serious efforts have also been made in China since 2000. Specifically, the China Association for Science and

technology (CAST), the Chinese Academy of Engineering and associated government ministries have accredited training programs, developed international cooperation and have gained provisional status in the Washington Accords (Loyalka et al. 2014).

Adapting to the international norms governing higher education today is the global norm. Thus, we could formulate the hypothesis that, beyond the historical influence that certain training models might have in emerging countries, training bodies are seizing opportunities for partnerships (and the models that go with them) where they are to be found, the idea being that they will play a part in developing the country rather than preserving a model that will provide a unanimous reference. The training systems developed in situ correspond to historical influences. However, with globalization and increased exchanges, these privileged links are not exclusive. Emerging countries are no longer looking to be dependent on one model. They are more likely to cherry-pick everything interesting for their country, without showing allegiance for one particular model.

To the question « What is the interest for a Moroccan school in being recognized by the Conference des Grandes Ecoles? » the head of training of one of the Moroccan graduate engineering schools replied during our interview: “To be in the CGE? It’s to be part of a network. There are several things: debates, the sharing of ideas. It enables homogeneity of approach”. This testimony whilst highlighting the homogenization that engineer training is currently experiencing on a planetary level, also reveals that were they not to conform they would renounce acquiring a certain reputation on the national and international scene. Thus, training bodies must adapt to international standards whilst meeting the specific requirements of companies, with all the friction that the two processes may create. Indeed, a « utilitarian » aim dominating curricular development can be observed, in the sense that an immediate economic and social practicality of the

education and diplomas constitutes the dominant principle of educational strategies (Lemaître 2015). This aim satisfies the norms of internationalization, in so far as adaptation of the curricula to international standards is perceived to be the means of adapting to the needs of companies and economic development and thus answers a set of injunctions relating to the market rules of higher education on a global scale (Elliot et al. 2011).

The adoption of international training standards and more generally the adaptation of the norms governing higher education in the world today participate in the homogenization of the training proposed. Thus, the differences between the historical training models seem to be increasingly leveling out. Hence, certain accrediting bodies, such as the CTI in France, for example, aim unequivocally to win recognition for their national model, whilst ensuring the integration of their training programs on a European and international level. Thus, the countries concerned reconcile opening internationally with closing nationally in an attempt to retain their own identity, as is the case for the French graduate engineering schools (Lemaître 2011). The example of weak membership of the CDIO in France can illustrate this position.

## **5. Conclusion**

The training system of engineers in the emerging countries that we have studied, like higher education in general, are undergoing great development. In many countries, the internationalized style of training programs, aiming to train a certain elite of industrial company executives, seem to be attempts to cherry-pick the best foreign systems have to offer and to build a model which is more or less in harmony with the cultural reality and needs of the country. Depending on the international partnerships and possibilities offered by partner companies, the higher education establishments grasp international

standards to design curricula which respond to the opening of the training market. This can be observed in Morocco, as in Mongolia and Vietnam.

The example of these countries enables the principles at work in the mobilization of international standards to be revealed. In Algeria and Morocco, engineer training is inspired by the French model. In Algeria, this allegiance is still apparent, even if all the developments implemented in France have not been adopted (more non-technical courses, development of internships etc). The other influences have been limited by the non-recognition of foreign establishments. In Morocco, the engineering schools following the French model have seen greater development, concerned by the directives of the French CTI and the French Conference des Grandes Ecoles. However, they are also open to other developments (the CDIO for example), even if they lack the means to adopt all the changes that they would like. One school can adopt different standards.

Similarly, the Moroccan higher education scene has opened up to foreign institutes and universities. The French model is no longer unique and can be mixed with others, becoming in some ways, a hybrid model. In Vietnam, the French system has also had success, even though it has been introduced more recently. However, it rubs shoulders with other more senior models (especially the American ABET). All of these systems rub shoulders without really mixing. In Mongolia, the Russian system is the basis in terms of engineer training but has evolved whilst losing its strong point (internships in company) due to economic constraints. Today, influences are multiple and this is considered positively by the State which means to multiply its offers of internationalization, in order to improve the quality of its training. However, as in Morocco or Vietnam, internationalization does not mean the blind and total adoption of standards. What has become apparent is that the benefits of foreign training have to be

cherry-picked to produce engineers capable of facing the great challenges unique to their country. Emerging countries often seem to be in a perspective of advocating a “situated innovation”, adapted to the context and the challenges of the country, some like Morocco, advocating a socio-technical approach to problems.

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