Studies on international equivalences of degrees

Comparability of engineering courses and degrees

A methodological study

by Anatoly I. Bogomolov

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Preface

This publication is the sixth in the series entitled *Studies on International Equivalences of Degrees*, the idea of which was approved by the General Conference of Unesco at its thirteenth session in 1964.

These are comparative studies which set out to establish the conceptual bases of the comparability of studies and degrees at the various stages of training and to ascertain the general criteria that will make it possible to determine international equivalences, thus simplifying recognition of degrees or diplomas obtained in other institutions at home or abroad.

The present study assembles the results of a survey undertaken in a number of countries in which there exist one or more systems of training in engineering sciences. These systems were selected because they are prototypes of which many variants are to be found in countries belonging to different regions of the world.

The results that the survey revealed are set out in such a way as to facilitate comparison between the degrees and diplomas awarded for studies in engineering sciences in the different countries. The results may also be compared with those provided by the comparative analysis of studies and degrees in international law, which are the subject of the fourth volume in this series.

The preparation of the study was entrusted to Professor Anatoly I. Bogomolov, Head of the Department of Methods and Studies at the Ministry of Higher and Specialized Secondary Education of the Union of Soviet Socialist Republics.

The work is intended primarily for three categories of reader: first, for all those who, in one country or another, are responsible for assessing the level of training of people wishing to take up studies in engineering sciences or continue their studies or research in a new institution for the purpose of specializing in these disciplines, or of those who wish to use the engineering knowledge and training they already have professionally in an administration or business, at home or abroad; second, for students and research workers who want to know the systems of instruction in this discipline and the degrees obtainable on completion of the various stages; and lastly, for comparative education specialists and educational planners for whom the pages which follow can provide information and material for comparisons as regards studies and degrees in engineering sciences.

The Secretariat of Unesco wishes to express its gratitude to Professor A. I. Bogomolov and to all those who helped in the preparation of this work.

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Problems concerning the comparability of diplomas

The broadening of close contacts among countries in solving fundamental scientific and technological problems with a view to ensuring the prosperity of a future society is an outstanding feature of our time.

In the past, major discoveries came from individual researchers who were not provided with adequate facilities for experimentation, the development of technology lagged behind that of science, and decades or sometimes centuries passed before such discoveries were placed at the service of mankind. Only a small fraction of people, drawn from the ruling class, had access to education in each country in the past, and for this reason education could not be a dependable vehicle for the transformation and development of society, there was no close relation between the economy of a given country and the orientation and academic excellence of its educational system. All this was bound to lead to a situation where each pedagogical and scientific school developed in isolation, and some institutions of higher learning, including the world's largest, were passive when it came to exchanging experience and incorporating progressive trends in training competent personnel and researchers from other universities of the same or some other country.

Now that the scientific and technological revolution is under way, science, technology and education are developing in a harmonious manner and at an ever-growing pace, and ideas formulated by scientists are translated into life and made to serve society within much shorter periods.

Society requires researchers and engineers to ensure that all discoveries should be made to benefit mankind as soon as possible. Large teams incorporating the talent of pure and applied scientists, test engineers and designers, technologists and specialists in other fields, have taken over from individual researchers whenever important scientific and technological problems are to be solved. Society is faced with ever-changing problems of world-wide significance, such as those involving the peaceful uses of atomic energy, space exploration, interplanetary travel, depollution of the atmosphere, and the development of supersonic aircraft, the solution of which is the concern of most, if not all, countries of the world, and problems of this magnitude can be solved much more quickly if researchers and practical experts of various countries pool and co-ordinate their efforts.

It can be presumed therefore that co-operation between countries for the joint solution of major scientific and technological problems will constantly expand. It is for this reason that countries need to have a clear idea of the

scientific potential of specialists and researchers—including those educated abroad or drawn from other nations—whose qualifications are certified by diplomas or other appropriate testimonials.

Whether attempts to solve scientific and technological problems are crowned with success depends primarily on the structure and standard of training of researchers and specialists. It is no accident then that the problem of perfecting the system of education and raising its standard of tuition should be a major concern of governments, scientific circles and others, with international co-operation in this field also increasing. Countries exchange professors and lecturers to a growing extent so as to share experience in training expert personnel, more and more young people are sent to take a complete or partial course of studies at foreign educational establishments. Comparison of diplomas or, to be more exact, of levels of education would make it possible for institutions of higher learning to avail themselves of the experience accumulated in other countries, with the result that the over-all level of training of specialists in all countries would improve.

The growing rate of the scientific and technological revolution makes it necessary for the developing countries to obtain assistance from the advanced nations in training expert personnel and researchers in a number of specialities, with particular emphasis on new branches of science, technology and culture. The youth of the developing countries in which some of those branches have not yet been raised to the desirable level are eager to obtain education and scientific qualification in those countries where such branches have reached a high stage of development.

Insufficient information on the levels of education and training of teachers and researchers in various countries quite often results in a situation where, on returning to his country, a young specialist or researcher educated abroad is either not recognized as a suitable candidate to occupy a post for which he has in fact been trained or is offered a much higher position than he is actually qualified for. In other words, diplomas, degrees and academic titles awarded abroad are either underrated or overrated.

When admitting young people to educational institutions or providing them with an opportunity to obtain or improve their scientific qualifications, it is indispensable to know the level of education or the scientific qualification they have acquired in their own countries.

It would seem that the purpose of expanding international co-operation, raising the level of education, and rendering mutual assistance in training specialists and researchers will be served if there is recognized comparability of diplomas, certificates and other documents attesting to the qualification of specialists and researchers at all levels.

It is no less important for those hoping to study or obtain a degree or academic qualification abroad to be familiar with the comparability of diplomas so that they can plan their careers in the country where they will be working on completion of their studies or after qualifying as a practical expert or researcher.

The problem of the comparability of educational or scientific qualifications

should be considered from two angles: university or academic, and administrative or legal.

University (or academic) comparability determines the eligibility of a candidate to go on to higher education or to undertake advanced research work if he has received an education or obtained a scientific qualification of a lower level at another educational institution or in another country.

Administrative (or legal) comparability is the term used when the civil service authorities, a professional association, an industry, or a research or educational institution wishes to assess a diploma with a view to establishing whether the holder meets the requirements of the position sought.

The bulk of graduates from higher educational establishments seek jobs in industry and various types of institution, so that it is administrative comparability that matters in the final analysis. However, the problem of comparability of diplomas should not be approached solely from the administrative or academic point of view. A university cannot train specialists and researchers without formulating the requirements that their graduates are supposed to meet in professional life. Hence the task of establishing university comparability and the task of determining administrative comparability seem to be mutually related.

A line of distinction between university and administrative comparability of diplomas is only drawn to counter the argument that studies to establish such comparability are doomed to failure in view of the autonomy of universities and their non-recognition of such attempts. It must be remembered that what firms and other institutions wish to determine is the functions that specialists and researchers can perform rather than the views of higher educational establishments on eligibility to proceed to higher academic degrees.

There is no doubt whatsoever that a solution to the problem of comparability of diplomas involves a host of difficulties and that it should be arrived at by easy stages and with some reservations at the initial stage. To begin with, the problem of comparability should not be extended to cover undergraduates who have attended or plan to attend lectures and undertake other types of academic activity in separate subjects. When tackling the problem of comparability, only those students should be considered who pursue their studies on the regular pattern and take a complete course on a full-time basis. Nor is it reasonable or even possible to compare the levels of education of 'regular' learners engaged in identical areas of study (in different educational establishments) in terms of separate years of study. In such cases, comparability of education should be established by universities with due regard to all local conditions prevailing at those institutions of higher learning at which the students concerned have studied or will pursue further studies.

The system of training specialists, teachers and researchers has its specific features in each country and has evolved historically in line with the specific economic, social, political and other local conditions.

The choice of disciplines in the training of engineers is governed in each country by the structure of individual industries and industrial enterprises as well as of scientific and cultural institutions. These structures are peculiar to

individual countries, so that the lists of specialties in which higher educational establishments in each country train expert personnel do not coincide either. The patterns of majoring for undergraduates also differ from one country to another, to such an extent that it is extremely difficult to compare specialties and majors offered by institutions of higher learning in different countries.

But the difficulties do not end there. In some countries, such as the U.S.S.R., undergraduates are supposed to have on-the-job training in industry in line with the chosen fields of concentration. Hence, when they graduate from a higher educational establishment, they are immediately qualified, without prior probation, to claim permanent employment and carry out the functions prescribed for the positions they occupy.

In other countries, such as the United States of America, on-the-job training is not included in the curricula, and graduates from higher educational establishments are therefore obliged to go through an additional period of practical experience in firms before they can start their careers in industry.

It may be safely assumed that there are no two institutions of higher learning whose curricula and syllabuses would wholly coincide. The titles of courses and the distribution of study matter as between various subjects as well as the order in which they are taken differ as a rule between different institutions of higher learning in a given country, let alone between different countries.

Indeed, in some higher educational establishments, majoring starts as from the second year of study, in others from the third, and in still others from the fourth, and, accordingly, the set of general science subjects is taken at different levels, too. However, on completion of the full course of studies, graduates from all these institutions of higher learning may have an education of identical level although the programmes for the second, third, or fourth year of study may differ as between those institutions, both in volume and content of schooling.

When discussing the comparability of levels of education, therefore, it is desirable to consider and compare only completed cycles of education—for instance, complete general secondary education or individual stages of higher education, completion thereof being certified by an appropriate diploma or degree.

For all the variety of specialist and researcher training systems, it would be wrong to say that higher educational establishments of different countries have no common objectives, as was the case in the past. Today, schools of higher studies in all countries are called upon to educate, within the shortest time possible, creative minds who can make use of all that has been achieved by world science and technology to ensure further scientific and technological progress and the solution of new problems posed by society. One is inclined to agree with G. L. H. Bird when he affirms that:

> ... there can be considerable differences in the structure of engineering education and training between countries A, B ... Z and yet these can be equal in esteem—the professional engineer is equal in abilities and worth.[1]

1. G. L. H. Bird, 'Some United Kingdom Traditions, Practices and Trends', *The Training of Professional Engineers. Fifth International Congress of Engineers, 27 September to 1 October 1971*, p. 28, London, The Institution of Civil Engineers.

Indeed, if one considers the advanced countries having diverse educational systems, one is bound to admit that scientific and technological problems of an identical degree of complexity, such as the development of supersonic aircraft or space vehicles, are solved successfully by their respective national experts. It stands to reason then that different educational systems can provide for the training of top-level specialists and researchers of more or less equal standing. To carry the argument further, one may suggest that it is possible to elaborate integral criteria suitable for determining a level of scientific training to be achieved with different educational systems. It would seem reasonable that such criteria should be established for completed stages of education alone. Consideration will be given in the following chapter to patterns of higher education in various countries of the world against the background of this suggestion.

Requirements to be met in training engineering personnel

Specific conditions under which engineering personnel are trained exist not only in each particular country but also at each institution of higher learning. Even the term 'higher education' seems to denote different things to different people.

There are countries in which any education based on a complete general secondary education is referred to as 'higher'. In some countries, higher education comprises a number of stages, each stage entitling the student to an appropriate degree or diploma—on completion of two, four, five or six years of study. The period of advanced studies for the highest academic degree would in some countries be regarded as the final stage of higher education. Advanced training of specialists graduated from universities is often considered as continuing higher education.

Varying interpretations of the term 'higher education' lead to high-school graduates being awarded different qualifications. It is a common practice for technical educational establishments to award the qualification of 'engineer' to their graduates, but the word is accompanied by a modifying additive to denote a specific level of schooling. As a result, a wide range of terms is in current use, such as 'professional engineer' and 'master engineer' (Poland), 'shop engineer' and 'graduate engineer' (Hungary), 'engineer' and 'graduate engineer' (Federal Republic of Germany), 'pre-engineer' and 'engineer' (Romania), 'degree-engineer' (United States), '*étudiant-ingénieur*', '*ingénieur*' and '*docteur-ingénieur*' (France), '*ingénieur diplômé*' and '*ingénieur technicien*' (Switzerland), etc.

The terms 'secondary specialized education' and 'technician' have come into being in recent years. The appearance of these terms was prompted by the expansion of specialized secondary education as an intermediate academic level between general secondary and higher. As the scientific and technological revolution got under way, researchers and engineers capable of creating sophisticated equipment, machinery, instruments and constructions, began to be in great demand in industry, agriculture and other spheres of material production. To make the work of these men more efficient, technicians were brought in on a large scale as assistants on auxiliary operations.

However, no hard-and-fast line has so far been drawn between specialists who obtain the qualification of 'technician' and those who are awarded the degree of, let us say, 'pre-engineer' or 'graduate engineer'. Nor is there any difference in the denomination of educational establishments—notwithstanding the fact that some of them are intended to train technicians and others graduate

engineers. Yet in both cases they are referred to as higher educational establishments.

Switzerland's *écoles techniques supérieures* enrol youths having an incomplete general secondary education (nine grades) and a practical training of four years.[1] An educational establishment of this kind offers a three-year course on completion of which the qualification of *ingénieur technicien* is awarded.

Practical training carried out for four years consists in mastering a worker's trade, and it terminates in the award of a federal qualification certificate (*certificat fédéral de capacité*), which serves to testify that its holder has received knowledge sufficient to qualify as a skilled worker. The certificate can only be obtained by taking an examination, which is designed to verify knowledge and check skills, in the following fields: (a) workmanship, professional knowledge, mechanical drawing; (b) calculation techniques, computation, native tongue, economics.

The contents of the examination lead one to conclude that practical training does not complete general secondary education and that therefore a graduate from such an educational establishment, who is entitled to the degree of *ingénieur technicien* after three years of study, has not even a complete general secondary education.

In his article, H. A. Gonthier goes on to suggest that the content of the training programme for *ingénieurs techniciens* (non-university level) in Switzerland should be altered towards improving the general-education, scientific and engineering aspects of schooling, and raising the entrance and leaving levels of the higher technical schools at the expense of practical training. Only if this is done can engineers of this category be recognized abroad, including the Common Market countries. It has already been laid down in Switzerland as a first step towards this goal that a technician engineer is no longer expected to have experience as a worker and that he should not be assigned an 'executive' role in the shop but should rather undertake counselling and guidance activities.

In French-speaking Switzerland, graduates from the higher technical schools are entitled to take an examination to obtain the degree of *Bachelier Technique*. Those failing may sit for an examination for a federal qualification certificate.

H. A. Gonthier admits that the practical training of Swiss technicians does not differ in principle from that of skilled workers and consists in developing manual skills for four years. Those completing the course are also entitled to a federal qualification certificate, which makes them eligible for a two-year course of theoretical schooling in one of the following three fields of concentration: mechanics, microtechnology and electronics engineering, with a choice between construction and exploitation.

Summing up the situation as existing in Switzerland, H. A. Gonthier says:

> ... la hiérarchie dans les professions techniques supérieures comporte trois échelons: les ingénieurs diplômés, les ingénieurs techniciens et les techniciens.

1. See: H. A. Gonthier, 'L'Organisation d'une Formation Pratique dans l'Industrie au Bénéfice des Ingénieurs de Niveau non Universitaire et des Techniciens', *The Training of Professional Engineers ...*, op. cit.

Other examples could be cited to prove that different meanings are ascribed to the words 'higher' and 'engineer', and this undoubtedly further complicates the already complex problem of formulating methods for establishing the comparability of diplomas, certificates and academic qualifications.

At this juncture the question arises of whether such designations as 'shop engineer', 'technician engineer' or 'pre-engineer' cannot be regarded as comparable to the qualification of technician. This has a direct bearing on the idea of revising the established practice whereby the word 'higher' is attributed to whatever level of education is fixed above 'general secondary'. In dealing with this problem it is also important to recognize that different qualifications are involved in the training of technicians and highly skilled workers.

There seems to be no objection to considering that secondary specialized education has different levels. But, in our view, the same can hardly be said with regard to higher education. The word 'higher' suggests only one interpretation. If higher education is taken to mean two different levels it would be more appropriate to classify the first level either as incomplete higher or as, say, secondary specialized of an advanced level. The word 'higher' suggests the final stage of education. The person who has received an education at this level embarks upon the road of independent creative activity and is expected to contribute to the development of science and engineering.

If the term 'higher education' is interpreted to mean only one thing, classification of engineers into professional, graduate, non-graduate groups and so on seems hardly possible. A person can be an engineer only if he holds a diploma attesting to higher education; in all other cases, i.e. if a lower level of education is involved, he should be regarded as a technician.

The time seems to have come to revise the description of individual levels of instruction by giving each one of them an appropriate definition and possibly arriving at a qualitative criterion.

It would also perhaps be expedient to determine a specific stage of schooling at which a specialist may be regarded as having completed higher education and beyond which he is expected to perfect his academic standard through various forms of advanced training.

To substantiate the above ideas, examples of technician training procedures will be given and statements by prominent scientists on the problems raised in the foregoing pages will be quoted.

Until recently, the category of technicians was treated in some countries on the same footing as that of highly skilled workers. The Education Act passed in the Socialist Republic of Romania on 13 May 1968 stipulates (Article 122) that technical and polytechnical institutes shall be charged with the task of training pre-engineers and pre-architects as engineering personnel intermediate between engineers and technicians (foremen). Appropriate arrangements have already been made in Romania.

In the U.S.S.R., the training of technicians, which dates back to the years preceeding the October Revolution, follows two distinct patterns: on the basis of incomplete general-education secondary school (eight grades) for three to five years (depending on the field of learning chosen) from 15 to 18 or 19 years