

## Biomedical Education for Clinical Engineers

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**Abstract** — Biomedical equipment Master’s degree is recognized by the French Ministry of Health, since its creation in 1975 under the denomination of “Specialization for Hospital Biomedical Engineers”. Since the new national status of technical staff in the public service by decree of September 5th of 1991, it allows to access directly to the level of Chief Hospital Engineer (first category, second class, by ordinance of October 23rd, 1992). Biomedical Engineers jobs in French hospitals are selected after an examination organized by the recruiting hospital. Master’s graduates are most often the best qualified.

### I. PEDAGOGIC PARTNERS

THE Compi gne University of Technology, the UTC, and the National School of Public Health, the ENSP, joined together in order to offer a Biomedical Equipment Master’s program. This Master’s program offers certified engineers an opportunity to acquire professional basis to become Biomedical Engineer in hospitals, or clinical engineer. This course, supported by many large hospitals, which have important human and equipment means, help students complement their professional skills. These hospitals also recruit engineers at the end of their specialization.

UTC is an institution of research, higher education and technology transfer, founded in 1972. It is composed of six engineering departments (Biology, Chemistry, Computing, Mechanics, Mechanical Systems, Urban Systems and Human Sciences). Three education structures receive 3300 students, divided into Initial Education (Engineering School), Doctoral School and Continuous Education.

The ENSP is a unique school in France, created in 1945 and installed in Rennes since 1962. Its first mission is to train health and social administration executives, hospital or social and medico-social structures managers (e.g. institutions for handicapped or elderly persons). It educates a wide variety of Public Health professionals, especially hospital managers and executives, but also head nurses, inspectors for social and health affairs, public health physicians and pharmacists’ inspectors, etc.

Every year, many French hospitals, both University

Hospitals and general, offer opportunities for students to do practical training periods. Various cooperations exist also with hospitals in USA, Canada, Great Britain, Germany, Sweden, Belgium and Switzerland. They allow students to compare and enrich their knowledge with other foreign models in health care.

Clinical structures in Compi gne participate actively in the education programmes. The new general Hospital, the Saint-C me Polyclinic and the CIMA (Advanced Medical Imaging Center, a partnership between medical entities and the UTC) offer such facilities as MRI, nuclear medicine, radiotherapy and assisted research laboratory.

### II. BIOMEDICAL ENGINEERS IN HOSPITAL

During these last 20 years, biomedical engineers became progressively essential advisors for hospital direction. The biomedical engineer is also the partner of different specialties physicians, paramedical staff, and medical equipment companies. In France, as defined in a national standard, the job of biomedical engineer inside public hospital includes 4 missions, the 2 first being the most important:

- New equipment purchase assessment, including the inventory of needs expressed by medical services, survey of the industrial offer, study of new technologies acquisition opportunity, participation to new services organization and design, writing of technical and legal requirements and calls to tender for public markets, definition of the good practices conditions for equipments (guarantee, maintenance conditions, technicians education, ...).

- Management of the installed equipments. It is there necessary to provide all aspects of maintenance, both with an internal hospital technical team, and through negotiation monitoring of external contracts with firms, including quality control and safety requirements.

- Education of users.

- Participation to applied research.

The Biomedical Equipment Master’s degree programme has served the educational needs of more than 2/3 of biomedical engineers working today in public French hospitals. Some graduates also integrated private clinics, military hospitals, and various organisms (ministries, assessment or accreditation institutions, or universities), and private companies involved in medical technology.

Many foreign engineers, coming from Europe, Africa, Middle East, Central and Latin America, also followed this Master course. They took advantage from the acquired

Manuscript received April 15, 2007.

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skills during the Master's specialization programme to respond to numerous needs met in their specific health care delivery environment. They often work as biomedical engineers in hospitals or regional maintenance centers, but also in education institutes, companies, and they have taken progressively large responsibilities.

### III. CURRICULUM

Education programme lasts 13 months from the beginning of September, every year. It is divided into 3 parts : the first one is based in the Compiègne University of Technology (6 months), the second part takes place at the National School of Public Health (Rennes, for one month) and the programme ends with a hospital practical training period of 6 months.

#### A. Education at UTC and ENSP

More than 150 lectures given by academics, physicians, senior engineers, hospital directors, industry specialists, are included in this programme, in such a way as to give various complementary points of view about medical technology related questions (technology itself, but also medical aspects, recent researches, economic and organizational implications). These professionals help the students to get familiar with the environment that they will work for in the next future. Theoretical teachings are grouped in thematic sessions lasting one to ten days. Many practical tests and experiments (such as MRI, nuclear medicine, echography, operating theaters, monitoring equipments, quality control,...) are performed. Medical services and factories visits complement theoretical courses. These have been generalized through a good cooperation between UTC, ENSP and hospitals in Compiègne and in Rennes, especially with the CIMA (Advanced medical Imaging Center), and also thanks to efficient relationships with biomedical equipment manufacturers.

#### B. Professional Thesis

The professional thesis represents an important part of students' work. It consists in a study based on a technical topic proposed by a senior hospital engineer. Topics concern medical technology [1,2,3,4,5,6], but also economical and organizational requirements [7,8,9,10,11,12] with major implications for the hospital. It starts during the same period as courses and practical training period. This work is spread over a 12 month period. The practical training period is useful for concept validation and carrying out of plan. Several assessors joined together with each engineer trainee, and a public presentation is given at the conclusion of the Master's programme. These papers are then edited as articles in the ITBM-RBM Journal.

#### C. Practical Training Period

The practical training period is organized in such a way

as to learn the biomedical hospital engineer professional skills. It lasts 6 months, it is carried out in a French or foreign hospital. The trainee is integrated in a biomedical service team, under the responsibility and the sponsorship of training experienced engineers.

At the end of the period, the professional work is presented in public together with the professional thesis.

### IV. CONCLUSION

The Biomedical Equipment Master's program of Compiègne University of Technology has been an important agent of the Clinical Engineering development in France, with more than 30 years of experience in graduate program with professional vocation and research. The professional thesis produced by UTC students on applied hospital subject represent a main contribution to the progress of the clinical engineer profession in France.

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