

The Newcomers: Humanities in Engineering Education

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Abstract – Engineering education has undergone a progressive specialization, creating a professional figure far from the ideal of the Italian Renaissance “artifex”, who united technical skills with a deep humanistic education. Today, instead, we are witnessing a radical change of direction: the need to respond more adequately to the complex challenges proposed by “technoscience” has forced various countries to introduce in the syllabus of engineering departments subjects such as ethics, anthropology, literature, history of technology or even aesthetics, which can be called *Engineering Humanities* modelled on the *Medical Humanities*. The recent literature on this topic shows that the inclusion of humanities in engineering education is considered indispensable for regaining the human factor in technological questions. Among the disciplines that make up the humanities, philosophy has a fundamental importance, because the anthropological and ethical reflection on the meaning of human and non-human is the necessary premise for a *human-centered technology*.

Index Terms – Anthropology, Education, Engineering Humanities, Ethics, Human-Centered Technology, Philosophy of Technology

INTRODUCTION

Many changes have been made in engineering education in the past two decades. The purpose of this paper is to explore in broad strokes the evolution of the relationship between humanistic formation and engineering education. Through a historical overview, this paper will present some of the stages that in the modern era have led to highly specialized engineering education, creating a professional figure very far from the ideal of the Italian Renaissance “artifex”.

The analysis will illustrate the change of perspective that has been manifested in recent years. The idea of an exclusively technical and highly specialized engineering education is being abandoned and the need to integrate technical preparation with humanistic formation is making itself felt. The aim of this paper is to offer a deeper understanding of the reasons for this change and to show the centrality of anthropology and ethics among the “engineering humanities,” manifested also in the attention given to these

subjects in engineering education magazines and in a series of initiatives that have been undertaken in various countries.

I. THE HUMANISTIC AND TECHNICAL EDUCATION OF THE ITALIAN RENAISSANCE “ARTIFEX”

The unity between technical knowledge and the liberal arts is paradigmatic of the *artifex polytechnes* of the Italian Renaissance. Personalities such as Michelangelo, Giulio Romano, and Verrocchio possessed technical-artistic competence and at the same time dedicated themselves to theoretical studies of subjects such as music or geometry, seeking to harmonize these disciplines with the practical objectives of their activity. In the Italian Renaissance, the expert in *ars aedificandi* incarnates the ideal of the complete man described by Pico of Mirandola, created as a being capable of dominating nature. Giannozzo Manetti, in *De dignitate et excellentia hominis*, affirms that the greatness of man is manifested in his capacity to construct, an activity also praised by Ficino as that which renders he who practices it almost “deus in terris” [1].

Leon Battista Alberti is a paradigmatic figure of the multifaceted character of the Renaissance architect or engineer, the representative par excellence of art-science, gifted with the capacity for speculative, imaginative, and practical competence.

When faced with new technologies, which in Alberti’s era regarded above all the field of civil engineering, the need to acquire new competencies was considered inseparable from philosophical knowledge. In his essay on Leon Battista Alberti, A. Grafti notes: “When, for example, in 1400, the construction of the Duomo in Milan was interrupted, the architects involved in the project participated in public debates regarding which form of arch is more resistant. Both factions made it clear that they considered it impossible to carry out such a discussion rigorously without reference to mathematics and Aristotelian philosophy of nature”[2].

Leonardo identified himself as an “unlettered man,” that is, ignorant of Latin and Greek. Still, he had knowledge, albeit indirect, of Ficino’s philosophy and his conviction that mathematical proportions constitute the divine structure of things, due to his discussions with Luca Pacioli, a mathematician friar who was an expert in the neoplatonic doctrines widespread in Florence [3].

The architect Andrea Palladio became capable of carrying out great works thanks to a careful reading of the works of

Vitruvio, which contained technical facts and philosophical precepts. In Palladio's formation, theoretical and practical knowledge, scientific and humanistic learning, were harmoniously combined [4].

II. THE SPECIALIZED EDUCATION OF THE MODERN ENGINEER IN EUROPE

A. France

In Europe, the first engineering school was born in 1747 in Paris, with the so-called *École des Ponts et des Chaussées* [5]. This event signals the beginning of the professionalization of engineering and at the same time of that process of specialization that will lead to the stark separation of technical and humanistic formation [6]. But it is in September of 1795 that the *École Polytechnique* is born, with the aim of forming the civil and military engineers indispensable for revitalizing the country's productivity and sustaining its war efforts. Napoleon Bonaparte conferred the status of military college on *École Polytechnique*, a status conserved for another two centuries [7].

B. Italy

In Italy, the origins of the first polytechnical schools, that of Milan and that of Turin, can be traced to the application of the Casati Law, promulgated on November 13, 1859. The law proposed a rigid separation between classical and technical culture. The scope of classical instruction was to offer the literary and philosophical culture necessary for higher education in state universities (Article 188). Technical instruction, on the other hand, aimed at careers in public administration, industries and technological professions (Article 272). [8]. The Casati Law established a two-stage subdivision of university courses for the study of engineering, the first for theoretical preparation, carried out at the university, and the second entrusted to specialized schools that needed to be created. In this way, the *Scuola di Applicazione per gli Ingegneri* was born in Turin, which in 1906 became the *Regio Politecnico*, and in Milan the *Istituto Tecnico Superiore* was founded, known from 1863 on as the "Politecnico".

At the *Politecnico* in Milan, the five-year program was exclusively techno-scientific. There were only two courses in humanities: foreign language courses and courses in Italian literature. But both soon came to have a merely decorative function [9].

Likewise, in Turin the program had an exclusively techno-scientific character. Some humanities courses existed – such as political economy and law courses – but they were entirely marginal, with a notoriously easy exam. [10]. Fubini, a mathematician and stable professor at the *Scuola d'Ingegneria*, did not hesitate to affirm that philosophy, as a "collection of sophisms," was not of interest to the future engineer, who "does not abandon himself to vague disquisitions" but prepares to confront and critically resolve diverse problems [11].

The rigid dualism of the Casati law would have produced a clear separation between the so-called "two cultures," the humanistic and the technical. The preparation of an engineer, characterized by extreme specialization but deprived of a global vision, would have ended up by producing the professional figure of a completely sectorial high-level technological specialist [12].

III. NEW CHALLENGES OF TECHNOLOGY, NEW NEED FOR HUMANIZATION

Around the middle of the twentieth century, technological development leads to an inversion in these tendencies regarding the formation of engineers, because a greater ethical understanding is sought in relation to technological activity.

The German professional society *Verein Deutscher Ingenieure* (VDI), reconstituted in 1947 after World War II, has been crucial for the dialogue between engineering and philosophy. In 1956, VDI promoted a professional committee called *Mensch und Technik*, which has given an important impulse to cultural exchanges between technology professionals and philosophers that foster cooperative reflection on the aim and implications of technological activity [13].

Technology nowadays is no longer just an instrument at man's disposal which from time to time presents problems that he can resolve on the basis of extra-technological criteria. It has turned into a *Weltanschauung*, a pseudo-world that imposes on man its laws and categories, altering his manner of thinking and feeling, of evaluating and planning. It has given way to a "new psychology" [14], that of the "technicized" man who, educated by technology, reasons according to the logic of technology, uses technological language and exercises his freedom within the bounds of technology. Efficiency and utility are the criteria that determine his choices. Utilitarianism, however, as H. Arendt incisively puts it, proves self-destructive precisely because it considers each end as a means to another end: "it is condemned to a never ending chain of means and ends without ever reaching a principle that can justify the category of means and ends, that is, of utility itself. The statement *for the end of* has become the very content of *in the name of*. In other words, utility equated with meaning inevitably leads to absence of meaning" [15].

Because of this, the most urgent challenge is that of interrupting the vicious cycle of means and ends in order to reach an end that is an end *in itself*, that is, an absolute and *ultimate end* which is not in function of any other end: "only in a strictly anthropocentric world where he who uses — that is, man himself — becomes the ultimate terminus that breaks the unending cycle of means and ends can utility as such acquire the dignity of meaning." [16] But to achieve this, it is necessary to reconstruct an image of man — the most authentic possible — through a thorough reflection on the notions of *man* and *human*.

By the term humanities we refer to those sciences which have as their object of study man and his understanding of himself. These sciences draw on various disciplines: philosophy in the first place, followed by literature, art,

history, and psychology. The humanities are commonly seen as being aimed at *understanding* or *comprehending reality* as opposed to the sciences of nature which are limited to *explaining phenomena*. This contraposition gave rise to a dichotomy between the so-called "two cultures": the techno-scientific culture on the one hand — oriented towards explaining facts through laws and controlling practical goals — and the humanistic culture on the other hand, concerned with the comprehension of meanings behind facts.

This contraposition between the world of facts and the world of meanings is a disadvantage for the techno-scientific culture which is increasingly patterned on a procedural rationality incapable of grasping the *Lebenswelt* — the world of life and underlying meanings. The same contraposition has dealt a severe blow to the humanistic culture which has ended up radically critical of techno-scientific progress, abandoning it to fate and refusing to vivify it. There is a need, therefore, for renewed effort to integrate the techno-scientific and humanistic spheres in order to recover a global vision of problems through a reciprocal relation between *explaining* and *comprehending*, a procedure that presupposes an intimate link between facts and meanings. It has rightly been said that "a fact explained without meaning is by definition inhuman"[17].

As we can see, the humanities are indispensable for regaining the human factor in technological questions and for a more profound reflection about specifically humanistic matters. Humanities can radically transform the otherwise exclusive horizon dominated by the techno-scientific paradigm where issues concerning the person and human nature — as well as related notions like man's corporeal nature, health, sickness, freedom, and work — are exposed to incessant redefinitions until they are made objects of adequate philosophical reflection [18].

IV. THE ROLE OF ENGINEERING HUMANITIES: THE PROJECT AND THE REALITY

A. Interdisciplinary Approaches

The "Manifeste de la Transdisciplinarité", written on November 6, 1994 and signed in Arrábida (Portugal) by Basarab Nicolescu, Edgar Morin e Lima De Freitas, represents an important stage in progressive realization of the need to return to a more unified approach to knowledge. In the intention of its signers, the *Carta* aimed to express the openness of today's technological and scientific professionals to lead science and its conquests beyond the confines within which a sectorial knowledge would tend to enclose it. As detailed in the preamble, the motivation is also of an anthropological nature: "Aware that the current proliferation of academic and non-academic disciplines leads to an exponential growth of knowledge, a situation that renders impossible a global vision of the human being". This task also has an ethical dimension because, in an era of great progress in knowledge, the lack of dialogue and circulation of that knowledge yields to greater inequality between those who possess that knowledge and those who do not [19].

It could be interesting to cite the text of two articles, 3 and 5: "An interdisciplinary approach is complementary to the disciplinary approach, because the confrontation among disciplines brings new facts to light, which act as a link between the disciplines themselves; this offers a new vision of nature and of reality. An interdisciplinary approach does not seek dominion over more disciplines, but the openness of the disciplines to that which is common to them and to that which exceeds them."(art. 3).

And in Article 5 we read: "An interdisciplinary vision is decisively open, to the degree in which it goes beyond the field of the exact sciences to push them toward dialogue and reconciliation, not only with the human sciences but also with art, literature, poetry, and interior experience." (art. 5). The inclusion of the humanities, specifically anthropology and of ethics, is a response to the pervasive question confronting technological activity as well as a solution to the need for rebuilding the unity of knowledge and ethical experience presently broken into fragments in the kaleidoscope of procedures and competencies. The humanities are not just a supplement to knowledge attached on the outside, as a sort of decoration for strictly techno-scientific subjects. Rather, the humanities represent a reference point for all branches of knowledge and technological activity.

B. Humanities in the curricula of US Engineering Faculties

Since the nineties in the USA there has been a growing need for integrating engineering education with humanistic sciences: in the educational standards fixed by the *Accreditation Board of Engineering* (ABET), there is a priority request to educate professionals "technically expert and ethically sensitive" [20].

The object of these teachings is synthesized in a 1990 article: "Humanities courses should furnish our students with the opportunity for personal reflection on the communal and personal meanings of the central ideas of culture [...] the humanities should provide the student with self-knowledge, the skill of critical thinking and the ability and desire to be a productive member of the community" [21].

At MIT (Massachusetts Institute of Technology), a Division of Humanities was instituted in 1932, which in 1959 became the School of Humanities and Social Science (SHSS), and in 2000, the School of Humanities, Arts and Social Sciences. One of its objectives, as can be read on the website, is "to relate the humanities more directly to science and engineering."

The US *National Academy of Engineering* (NAE), in its 2000 annual meeting, reflecting on the challenges to engineering education in the third millennium, identifies engineering ethics as an emerging area that needs to be taken into account in professional preparation, because of the "enormous impact of engineers on individuals and society" [22].

The key category for such formation is the notion of "professional responsibility"[23], which is the result of a series of objectives synthesized as follows: "Teaching engineering ethics [...] can achieve at least four desirable

outcomes: a) increased ethical sensitivity; b) increased knowledge of relevant standards of conduct; c) improved ethical will-power (that is, a greater ability to act ethically when one wants to)” [24].

Passing from goals to practical realization still requires time: in the United States, the engineering faculties that include an ethics course in their curriculum are still a minority [25]. In spite of the clear success of this inclusion, it is necessary to overcome on the one hand the inexorable difficulties of the budget, and on the other the perplexities regarding the real possibility of integrating such courses with the others and regarding which teaching methods to use [26].

C. Humanities as newcomers in the curricula of European engineering faculties

In Europe as well, even if with slower concrete results, there is a growing sensibility to this topic, as manifested in 2002 at the thirtieth congress of the European Society for Engineering Education (SEFI) [27]. Besides various papers, an entire session was dedicated to “Awareness of Ethical and Communication Issues in the Education of the Renaissance Engineer.”

Already in 1998, during the Helsinki congress, SEFI promoted a working group to study the topic, “Ethics in Engineering Education”, in order to activate the proposals expressed the previous year in the Krakow congress.

In France, the *École Polytechnique* itself since 1976 has included a *Département de Humanités et Sciences Sociales* (HSS), which aims at integrating technical and scientific education with humanistic formation.

The presentation of the *Département* highlights this goal of unification: “It is along the lines of dialogue and exchange that the formation and teachings given by the department is carried out. This not done as an attempt to question the evidence, certitude, or models of the exact sciences, but on the contrary as an invitation to put them in perspective in relation to the fundamental contributions of human history, of society, or simply of the character and creativity of the individuals that create, learn, use and transform them” [28].

In Valencia (Spain), the curriculum of the Engineering Faculty of the *Universidad Politécnica* includes a course called “Engineering Ethics,” and the *Universidad de Navarra* of San Sebastián includes two philosophical courses in its engineering curriculum, Anthropology and Professional Ethics.

D. The situation in Italy

In Italy, in the Engineering Faculty of the *Politecnico* in Turin, it is possible to choose among three humanities courses: History of Technology, Environmental Law and Philosophy and Science in the 1900s. The faculty of Building Engineering at the *Università di Chieti* offers a choice among Aesthetics, Logic, and Philosophy of Science. The faculty of Informatics Engineering at the *Università di Firenze* offers Logic or History of philosophy.

Still, a careful study that prepares adequate methods and content for the teaching of these disciplines in a way that does not run the risk of treating them as inferior to other

courses is necessary. As it has been noted: “Humanities in the context of a technical education cannot be considered as disciplines of relaxation, as entertainment (with the teacher as entertainer), as a security valve for stressed students, or as an embellishment of the curriculum” [29].

The need for anthropological and ethical education appears to be especially important where engineering is applied to medicine: the inherent threats cannot be ignored. In summary, these threats refer to the dehumanization that high-tech medicine can involve, if unable to reconcile the technological function with its meaning and purpose, that is, the professional dimension with the human one. The inclusion of humanities, specifically of anthropology and ethics, in the Biomedical Engineering Department of the *Campus Biomedico* (Rome) is a response to the pervasive question confronting technological activity as well as a solution to the need for rebuilding the unity of knowledge and of moral experience presently fragmented in the kaleidoscope of procedures and competencies.

V. HOW INCORPORATE THE HUMANITIES IN ENGINEERING EDUCATION: A PROPOSAL OF CONTENTS AND METHODS

A curriculum of Humanities in a Faculty of Biomedical Engineering should structure itself in the following manner:

BASIC COURSES	CONTENTS
Anthropology of Technology	Anthropocentric cosmovision and technocentric cosmovision. Notion of human person. Distinction between categories: Natural/Artificial; Human/Non human/Post-human. Distinction among: improving/strengthening/substituting human capabilities. The body-mind problem. Healthcare, disability and technology. Anthropological implications of Biomechatronics: the cyborg.
General Ethics	What does it mean for a biomedical engineer to be a <i>good</i> engineer? The meaning of professional responsibility: technical competence and ethical dispositions and attitudes.
Applied Ethics	Axiological system for the resolution of problems of technological activity. What does it mean humanization? Characters of a Human-Centred Technology.
OPTIONAL COURSES	CONTENTS
Philosophy of Science	Science, Technology and Technoscience. Philosophical reflection about the scientific methods. Logic of the scientific discovery.
History of Biomedical Technology	History of the use of technology in Medicine. The importance of technological tools in the change of the disease image and the doctor-patient relationship.
Technology and Literature	Analysis of science fiction literature: genre and contents. The link with science fiction movies.

The most suitable method to teach Humanities is “Socratic dialogue”, based on the presentation of the subject, analysis and general discussion. The lessons should be integrated from compiling of papers involving actively students.

CONCLUSIONS

The historical evolution of the formation of engineers shows how an initial multifaceted formation evolved into radical specialization. This change was in part necessary to create professionals capable of responding to the complexity of technical progress. But modern technology has a genuinely novel character. It is no longer just an instrument at man's disposal which from time to time presents problems that he can resolve on the basis of extra-technological criteria. It has turned into a worldview, with its own laws and categories, that threaten to erase the distinction between human and nonhuman. Without this awareness, the frontier of the technologically possible may not stop at the limits of what is ethically justified. This explains recent demand to reconcile technical and humanistic education, and the proposal, carried out much sooner in the USA than in Europe, to include the humanities in engineering curriculums.

However, as the facts show, it is still necessary to define the methods and content of these courses with greater precision, to ensure that they do not have a merely decorative function. In particular, we need to assign a central role to philosophical reflection, which constitutes the backdrop of every question about man and technology.

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