Considerations on the mechanisms for optimizing the relationship between the science and engineering of metallic materials from the perspective of the professional development at university level

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Abstract. The paper presents a few considerations regarding the engineering training in the field of metallic materials, according to the present situation in Romania. It presents the following aspects: the issue of engineering training at the specific transition from the centralized economy to the market economy functionalities; problem-solving through personal experiences related to engineering in recent years; structuring the specificities in materials engineering; calibration of the training systems; determining the blueprint of training systems; considerations on the evolution of training systems; conclusions and assessments regarding the priorities of the structure of training in materials engineering. The general conclusion, by addressing the activities carried out within the analysis, is the necessity, at least in Romania, to respect the specifics of engineering activities and to avoid overlaps with what works at the level of “material science”. This is true for all levels of engineering training: bachelor’s degree, master’s degree, doctoral studies.

1. The issue of engineering training at the level of the transition from the centralized economy to the functionalities of the market economy

In Romania, during the last three decades, the necessity of a real calibration of the specializations which function at university level with the existing requirements in the economic development, was put in question. All these during a difficult period, determined by the institutional arrangement of the economic-social change, to the requests of moving from a centrally managed economy to the market economy mechanisms.

For a responsible positioning in this approach, we attempt to build a design system for materials engineering training systems, which can be extended to other systems. The schematic presentation of the analysis, which is structured in the present paper, is shown in Figure 1.

The general structure of the thesis, using the principles of critical engineering thinking, is based on a methodology for optimizing material engineering training systems that is fueled by two basic modules in the assessment of the existing situation: M11 - knowledge of engineering training issues from the perspective of economic and social competitiveness and M22 - assessment of training systems in materials engineering. The first module (M1) is fueled by the following investigations related to the
knowledge of the following issues: M11 - the issue of engineering training at the level of the transition from the centralized economy to the market economy; M12 - problem-solving through personal experiences related to the engineering of recent years; M13 - structuring of specificities in materials engineering. The second module (M2) is influenced by the following actions: M21 - calibration of material engineering training systems (SFIM) and M22 - determination of the SFIM blueprint.

Figure 1. Design scheme for “TRAINING SYSTEMS IN MATERIALS ENGINEERING” (TSME).

Methodological processing generates two levels of analysis in the socio-economic context of material engineering training systems: considerations on the evolution of training systems and assessments regarding the prioritization of assurance of SFIM functionalities. Both provide data on designing material engineering training systems using the principles of engineering training.

The presented methodology is a synthesis of a larger work devoted to the engineering training in Romania, which will have the title: Soporan, “The university engineer and the design of truth”. In the analysis of the engineering training systems the following studies are noticeable [1-3].

2. Problem formulation through the personal experiences of engineering in recent years
The personal experiences of the main author were determined by the complex actions of recent years, weighing a nearly 40-years worth of experience in engineering, with important passages through
professional positions that focused on the execution, conception and design, research, construction and technology, university professional training, public administration at central and local level or parliamentary activity.

All things considered, we notice that there are some mutations at the university level environment of engineering training, the most important of which is related to the fact that the specificity of the appreciation of the engineering work is far inferior to the scientific papers. It is, perhaps intentionally, forgotten that there is a market-driven cycle in which the results of scientific research are continued, through complex entrepreneurial actions, technological development, realization and materialization of products or services validated by demand and supply mechanisms in an ever increasingly globalized presence.

At present, in the institutional appreciation of the activities of those involved in engineering, there aren’t any criteria which refer to the knowledge and capitalization of activities in the very defined specificity of engineering. In this respect, there are abnormal situations when many teachers with important positions in the educational process have not included in the professional portfolio at least one day of organizationally validated engineering activity, nor have they capitalized in the socio-economic mechanisms.

This situation can be appreciated as dramatic from the perspective of the engineering graduates, in the sense that is affected the future of the professional qualification to the requirements expressed by the employer, by ensuring the skills and aptitudes required by the engineers in a functional organizational context.

A delicate situation is found at the level of doctoral theses in the field of engineering, which unfortunately pursue only the materialization of the researches only through the inheritance of some scientific works and less by the realization or the substantiation of some engineering works, overlooking - at this level of training - the differences that exist between the “science” and “engineering” of a particular field. The most affected, speaking from experience, being specializations in the field of “materials” or “environmental protection”.

Considering the battle carried out in terms of the two ways of approaching a field, we think it is important to define the specificity of each approach, in order to diminish the opposing character and increase the complementarity of the two tendencies. It is appreciated that both tendencies are in the discovery of truth, and the validation process gives the specificities of the differences between the “science” and the “engineering” of a field. At the level of “science”, the truth seeks to discover “what is”, validated, as a rule, by its “correct” or “false” logic, and in the “engineering” field, the search is replaced by “designing” – a process in which the result (i.e. an optimization) becomes more important than the “discovery” that creatively optimizes the integrating conceived possibilities.

Without vulgarizing this differentiation, we urge you to recognize the reality that a house (or a machine) is firstly designed and then realized. It is true that within the design activity are included the sought-after truths of the researches of several fields, but the specificity of the conceptual activities remains dominant in materializing the novelties that appear in the fundamental sciences.

In concluding this attempt of differentiating the specifics of the two approaches, which we consider to be complementary, I believe that the process of attacking and correcting the “error” specific to “science” can be continued with designing activities of generating the truths, specific to “engineering”. Thus, we can assert that at the level of engineering, the truth is determined by the design and justification of the solutions given by situations that are suitable for the intended purpose. Based on the same reasoning, it is appreciated that “materials science” studies that which exists, often without specifying utility, and “materials engineering” creates that which does not exist, for a well-defined utility purpose.

In conclusion, we address the following call to the ones who are in the beginning stages in the field of engineering: “Explore engineering deeply, connect to the experience of others for whom engineering means how to be (action), share your discoveries with those who are professionals in the field and within the groups you are part of, calibrate your steps in the beginnings, and by doing so, refine your understanding in designing the truths sought after at the socio-economic level.”
We must notice that there are many traps in the early stages of an engineering career, the most dangerous of which is determined by the professional belief of many that engineering is just a forced experiment, often sophisticatedly carried out at the with inappropriate equipment to the intended purpose.

Figure 2 summarizes some of the questions generated largely by the personal experiences at the engineering level, which await answers for a good placement of the materials engineering training at the level of the specific issues.

![Structured questions from the engineering experience to improve the functioning of training systems.](image)

Figure 2. Structured questions from the engineering experience to improve the functioning of training systems.

3. **Structuring specificities in materials engineering**

The analysis of the specificities of materials engineering and the way in which it is present at the level of the university education is accomplished through the following stages: the critical presentation of the engineer’s diversified missions, the position of the materials engineer as an intermediary engineer, the conditionings of the materials engineering specificity or the values to which the engineering material refers to.

The diversified missions of the engineer are outlined in Figure 3.
Figure 3. The quadrant of the engineer’s diversified missions.

It is emphasized that the engineer’s traditional tasks are supplemented by other activities, related to commercial, certification and regulatory activities, risk insurance, development of internal communication processes, or external operation of computer systems or adaptation to the numerical industry, vision-building and strategic design or entrepreneurial and personal development.

In the context of the mutations that have taken place and are still taking place in Romania, a few questions arise: What does materials engineering refer to?, Metal materials engineering or Metallurgical engineering?, What is the relation between science and engineering of materials, knowing that the science studies what does exist, and the engineering creates what it does not yet exist, through the tools at its disposal?, Can doctoral thesis in the field of engineering sciences be guided by specialists who have not completed engineering studies?, In assessing engineering do only works and scientific works matter; or is taken into analysis the engineering work as well?

The responses await, and the following can be used to support a correct approach for an accurate understanding of the materials engineering.

In order to have a complete picture of the elements of the material engineering and to demonstrate the mediation capacity, Figure 4 presents the elements of the definition to be taken into account.

In the context of the analysis, it can be said that from the perspective of constructive-functional engineering, the material means functionality, form, processing, safety, environmental conditions and many other responses to the conditionality imposed by socio-economic perspectives. Therefore, from the perspective of integrating engineering, materials do not mean only properties, structure, morphology, composition, and many others that give substance to the above.

From the perspective of integrating or intermediation engineering, which is specific to the engineering of metallic materials, it is appreciated that, as a whole, we have to deal with standardized or at least regulated materials, with well-established procedures and technologies, with an efficient and creative infrastructure and, last but not least, with engineers who, for well-formulated themes, offer solutions or validate constructive forms, designate technological parameters through procedures where
the technological infrastructure, utilities and competencies of the human resource give value to activities in a manufacturing network.

![Diagram of Materials Engineering elements]

Figure 4. Elements defining Materials Engineering.

These are to be validated by the other functions of the entrepreneurial tool. Therefore, it is noted that the complexity of the missions performed by the materials engineer can be deciphered. Moreover, it is appreciated that materials engineering is supported by a multitude of occupations and the presence of important actors from several areas: economic-financial, manufacturing industries, customers, suppliers and partners, research bodies and institutional structures of regulation and certification.

The correct appraisal of training programs by means of the above mentioned elements, which take into account the conditions imposed even at the level of establishing the materials in the manufacturing processes: conditionalities of functionality - (functional form); safety assurances in assurance of functionalities - (ensuring the behavior of the material to the conditionalities of the fulfillment of the required functionalities or the safety in operation at the imposed demands); machining conditions - (machinability); environmental compliance conditions - (environmental protection); conditions for increasing the service life - (durability); end-of-life disposal (material, energy and environmental recovery of products to be eliminated and smart degradability at the end of the life cycle).
To all these, an increasing pressure is put on some conditions where engineering is a growing important part. Among the most important are the following: environmental conditioning; socio-economic functioning; strategic use.

From the perspective of the material analysis, within the engineering training program it is necessary to introduce a new discipline called “the value of materials from the perspective of the circular economy”. Analysis reporting should be done at the following values: functional value; the material value; energy value; the environmental value; social value; strategic value. They are related to the three states: past, present and future.

4. Calibration of training systems in materials engineering

By performing our own analysis on the materials engineering training systems, of which the most recently developed in a doctoral thesis [5], it was found that the calibration formula that gives the best results, passes through the following steps: past events with teachings for present deployments, valorization of the positions of forerunners, critical analysis of the positions of specialists regarding the evolution of educational systems and the realities of the world in which we live, the evaluation of the public policies that influence the engineering training; the influence of institutional positions and the involvement of professional associations.

4.1 Learning from past events

In a parliamentary debate held at the Deputy Assembly between March 28, 1932 and April 12, 1932, an important topic (then and now) was debated, namely the “Law of University Education”, motivated by the competition existing at that time between the “university technical institutes” and the “polytechnic schools” in the desire to reach an agreement to ensure the good functioning of higher education and the country’s economy. The lessons for the present times are all the more important as the participants were the scholar Nicolae Iorga - the president of the Council of Ministers and the Minister of instruction, cults and arts and a number of personalities who played an important role in structuring the higher technical education, We mention here N. Vasilescu-Karpen, Constantin D. Bușilă, V. Vâlcovici, N. Dânăilă or Traian Dimitriu-Șoimu. The teachings, which are still valid today, are shown in Figure 5.

4.2 Positions of the predecessors on educational systems

The history of the evolution of educational systems, especially those operating at the level of engineering training, is very important in the calibration of the features currently in operation. For their value as the lessons to be applied consistently at the level of the development forecast, we will present some of them:

“The existence of a nation implies balance in the presence of the professions exercised. Alongside artists, scientists, lawyers, men of letters, must be small entrepreneurs, traders, farmers” [7].

“We always treat social issues seriously, we even consider it an important mission, which is why we put a special emphasis on education. This was not restricted to young people, they had to be educated and senior practitioners to be able to educate those at the beginning of their profession. The success of education is reflected in the comparable productivity of our plants with those developed abroad” (Izso Diamant, General Manager of Wire Industry S.A., 1940).

“Young drivers and engineers on entry into service often have to work as workers and in any case practice for at least a year. Only after this practice do they get a definitive division of assistant at a certain workshop, and then, after 2-3 years, they will become heads of workshops with leadership and responsibility. Gradually, they are given more and more rights and duties, leaving more and more initiative and the liberty to lead, organize and bring improvements. We have found that leaving them with the initiative and leadership, even at the risk of making mistakes, they work with more ambition and takes shorter time to go into leadership. The condition, however, is to pass at least a year of practice, during which time all the manufacturing processes, the organization, the treatment of the workers, the testing laboratories and, implicitly, the quality of the articles have to be known. After a
period of twenty-three years, in which they took the necessary steps to manage the workshop and became capable of reforms and improvements, we usually send them to study trips abroad.”

“A great industry like ours has not only a strictly commercial and technical mission, but also has a great cultural and national mission” [8].

Figure 5. Structured questions from the experiences of engineering to improve the functioning of training systems.

Presentations of historical value have been made in several papers by the authors on this approach.

4.3 Assessing the positions of specialists regarding the evolution of educational systems and the realities of the world in which we live (development assurance)

Any construction in the field of materials engineering training, without taking into account the position of specialists in the field of adaptation of educational forms to the new socio-economic realities, is doomed to failure. Without dwelling too much on these, here are some of the positions expressed by Ken Robinson, one of the most important specialists in the field:

“Universities must consider the following realities of the world in which we live: the transformation movement with an increasingly global impact, in which the relative tranquility of the past does not have the natural continuity of the present; development or even survival is related to the capacities we have and we manage to do it with maximum efficiency; educational systems are bound to find a formula in which new situations require new thinking and action different from those of the past, triggering the understanding that saving communities and nations becomes reality by developing individuals at the level of new demands. “Complexity growing economies requires increasingly sophisticated skills: global perspicacity; knowledge of different cultures; technological literacy; entrepreneurial skills and the ability to lead more and more complex organizations The winners will be the ones who will act in the following directions: Those who will have the ability to imagine services, new opportunities to attract the workforce; Those who will receive the correct and true education; Those who will have the vision of not treating creativity as a luxury, but will appreciate it as an essential part of personal safety and fulfillment. The essence of the relational process is given by the
relationship between the learned (teacher) and the learner (student, student). If one of the parties disappears or does not meet the requirements of achieving the proposed goal or the relationship does not work it means that there is no educational process or there is a damaged one. For example, if students do not learn, for various reasons - which is said very often - there is no education anymore.” (Ken Robinson).

4.4 Analyzing public policies that influence engineering training

Even if sometimes it is not openly shared by decision-making structures, universities should have a dual stance: influencing public policies and developing means of efficiency. Without going into the details of this mechanism, there are some of the European positions that influence engineering formation:

“The priorities of the new agenda for higher education highlight the following: combating future skills inconsistencies and promoting excellence in skills development; strengthening inclusive and connected higher education systems; ensuring that higher education institutions contribute to innovation” [9].

At the same time, we must also acknowledge public policies addressing the issue of correlation between university education and labor market requirements, increasing the inclusion of graduates, and enhancing the contribution to innovation and community development.

4.5 Influence of institutional positions and involvement of professional associations

The construction of engineering training systems must correlate their actions according to the institutional positions and actions as well as the formulations of the professional associations. Not accidentally, given the experience of the TUCN’s “Center for the Promotion of Entrepreneurship in the Sustainable Development”, it highlights the importance of entrepreneurial constructions at the level of university education in the field of materials engineering by using the positions expressed in the Oslo Agenda. One of them is expressed in the following:

“The development of entrepreneurial education is sensitively affected by the internal organizational structure of educational institutions. Faculties and departments tend to work separately, which creates multiple obstacles for students to pursue interdisciplinary courses. Also, traditional education methods do not really foster the development of entrepreneurial reflections. Interdisciplinarity and pluridisciplinary collaboration are indispensable in the development of entrepreneurial skills. Entrepreneurs and business professionals are rarely involved in study programs, not considering that the involvement of real entrepreneurs in higher education can compensate for a lack of practical experience observed in the current generation of teachers. At the same time, European higher education institutions do not cooperate sufficiently and effectively with older students who have successful entrepreneurial experiences. Among other things, the mobility of teachers and researchers between higher education institutions and enterprises is, as a whole, very low, and it is not actively encouraged” [10].

Even though the statement dates from 2006, educational programs at the level of metallic materials engineering should take this into account, since true development occurs as specialists will be able to meet the requirements of other areas for which the required functionalities start from designing the "appropriate matrix" of the proposed goal.

A major concern of professional associations is related to the way in which the preparation of doctoral forms takes into account the skills needed to carry out business activities. The importance of the following groups of competencies are appreciated: understanding business operations, autonomy in project management, openness and ability to interact. In this context, steps are being taken to design a business competency reference from the point of view of doctoral studies [11].

In the form under discussion, the professional profile of Ph.D. in science competences is grouped as follows: "knowing the specificity of the field in which it is acts (expertise and research methods, information management, evaluation of the problem, development of competencies specific to the field); personal and relational qualities (analysis, synthesis and critical spirit, openness and creativity,
engagement, integrity, balance, listening and empathy, negotiation, collaboration, communication); activity management and value of creation (project management, change management, risk management, decision making, financial resources management, staff management and team management, results production, intellectual and industrial property, customer orientation); strategy and leadership (strategy, leadership)” [12].

Unfortunately, Romania has not generated a true debate about the professional profile of graduate students. This is all the more necessary since, at the level of training existing within this area, a major confusion is created between the theses elaborated in “materials science” and “materials engineering”.

5. **Determining the blueprint of training systems in materials engineering**

Engineering training, as in many other professions, is a particularly complex process that is influenced by many factors that provide socio-economic functionalities in a given space. In order to understand and clarify their mechanisms and dynamics, a synthesis on the regulatory framework is presented which, through qualitative and quantitative knowledge of the economy, can be the basis for the determination of the mark of the systems of training in material engineering.

From the perspective of the relationship between the human resource and the economic development, we are dealing with four essential regulations: regulation of activities requiring engineering training; the regulation of engineering-specific occupations; regulating of engineer-specific qualifications; regulation of educational and training activities.

For optimal functioning of activities and ensuring social satisfaction, it is important that there is a close link between the economic activities carried out, the existing occupations and the qualifications achieved. Any disruption, in correlating their operation, can cause serious damage, many of which are long-lasting.

Therefore, the question is related to finding mechanisms that can determine the functioning of these systems in a true symbiosis, determined by the present or future demands imposed by market dynamics.

It is considered that the optimization process should start from the activities that take place or will be carried out at the level of the economy, followed by an analysis of the necessary occupations to be performed within them and only then in the establishment of the qualifications necessary for the professional assurance of the occupational deployments mentioned.

The independent development of these systems outside the market economy can bring great economic harm to individuals and to the development of communities and society as a whole. Thus, regulated business activities or public institutions provide the first test of success by assessing and recognizing the economic value that is created. The second exam is given by how the human resource is calibrated in relation to the expected activities and institutionalized occupations. A failure in this area creates pressure on the qualifications and the level of the system that generates them. This third area should be the third exam. Practically, the exam provided by the qualification system is not a direct one, but it comes after evaluating the other systems. The reaction time and speed of training are important elements in ensuring their efficiency, and there is not always an institutionalized correlation of training systems with signals from the socio-economic complex.

If economic activities are propelled or limited by market signals, the same thing does not happen at the level of educational and educational activities, and there is the predilection to continue free exercises to ensure the wishes of those who work in this area, insensitive to the signals that appear externally.

This paper aims at trying to unravel the constructions to be provided at the level of the professional training that works in the field of materials engineering. Given that at the level of ingenuity two major areas are identified, that of substrate engineering and material action in the assurance of functionalities and the engineering of non-material action, in the following the analysis carried out stops at the first category.

In Romania’s academic environment, in the fundamental field of “engineering sciences”, there are 25 license areas, of which the following are related to the engineering of metallic materials: Mine, oil
and gas (5 study programs); Mechanical Engineering (15 study programs); Industrial Engineering (14 study programs, examples: Welding Engineering); Applied engineering sciences (10 study programs, examples: Biomaterials and medical devices); Materials Engineering (5 study programs, examples: Materials Science, Material Engineering, Applied Informatics in Materials Engineering, Biomaterials Engineering); Environmental engineering (8 study programs, examples: Waste recovery engineering); Engineering and Management (10 study programs, examples: Economic Engineering in Chemical and Material Industry).

In the fundamental field of “Mathematics and Natural Sciences”, the branch of chemistry and chemical engineering, the field of “Chemical Engineering”, operates 14 study programs, many of which refer to “materials engineering”.

Unfortunately, in Romania, if we compare the qualifications with the current study programs from the materials engineering perspective, there is no overlap between the regulated specializations from the perspective of the qualifications with the institutionalized study programs.

At the same time, the engineer's diploma is issued according to level 6 qualification of the “International Standard Classification of Education” [13], to the bachelors after four university studies, and the master studies, carried out for over two extra years, do not reinforce the initial title in engineering.

Practically, even though the master’s training consolidates the engineering training, it does not have labor market coverage. Therefore, the master’s studies, although being a continuation of engineering studies and practically a strengthening of specialized training, still they do not find pragmatic incentive recognition, both at the level of the title and at use on the labor market.

The Ph.D. is assessed at the European level as being the one specific to the eighth level of qualification. Thus, the doctorate, initially perceived as only a scientific title, is currently a qualification, which should be properly regulated in its use at the labor market level.

According to the way this title is granted and with the specification that there is no title of Ph.D. engineer, but only that of Ph.D. in “engineering sciences”, without the corresponding institutional definition of the last term, it is appreciated that at the level of the labor market there is no sufficient coverage for this category of graduates of the third university cycle.

6. Considerations on the evolution of training systems in materials engineering in Romania
The historical approach of the engineering training activities is structured on the following specific levels: preliminary accumulations, structuring of the engineering formation according to the European models, the accentuated industrialization and the transition to the market economy, with the particularities of the casting production.

In relation to the above-mentioned periods, we consider from a qualitative point of view that the evolution of the material engineering specialization had the following stages:

- the stage of introducing in the general engineering training of “general technological character” disciplines, where some chapters present the problems of knowledge and processing of materials;
- the stage of specific engineering training in the institutional structure of metallurgy specialties, namely in the routes identified from raw materials to the production of shaped products or materials used in different industrial branches (metallurgical engineering);
- the stage of incorporation in the engineering training of a multidisciplinary technological training system, determined by the following elements: the new technological developments in the materials used, the new creations within the technological infrastructure and the evolutions at the configuration level of the obtained parts and the new fields of use, which go beyond strictly metallurgical training;
- the stage of inclusion in the specific training of elements related to the new conditions imposed on industrial activities, in particular those related to the digitization of activities and the responsibilities required throughout the life cycle of products, which have successively covered the following formulas: job security, the environment, sustainable development, the
requirements of ensuring the green economy and the demands imposed by the transition to the circular economy. The details of this approach were made at the level of castings systems in the manufacturing of cast parts [5].

7. Conclusions and assessments regarding the priorities of the structure of the materials engineering training in Romania

In a synthetic formulation, which aims to be attractive for those who want to embrace this profession, Figure 6 presents the elements that define the profession of a materials engineer.

In conclusion, it can be said that the profession of a materials engineer is a multidisciplinary one, at the level of all industrial activities and it constantly evolves by generating new materials, the new developed processes and the new conditions, especially those related to ensuring ecoresponsibility.

From our own experience and perception of socio-economic development, I believe that the engineering training should have several levels of training, correlated with qualification levels. In a proposal, which should have a consistent justification, engineering training should be done as follows:

qualification level 5 - Basic engineering or technological training, run over 2 years, and certified by a “university degree in technology” or “university diploma superior technician”; qualification level 6 - engineering training at the undergraduate level, where it is run on the 3-year course, and certified with a bachelor’s degree in engineering. This form can be admitted for the third year and holders of the previous level diplomas, following an admission exam; level of qualification 7 - engineering training at the master’s level, carried out over 5 years, and certified by the engineer’s degree.

The proposed pathways, presented in Figure 7, are as follows:

1 - the direct pathway of material engineering. It is carried out over 5 years, with the license exam in the validation of the lower cycle in the 3rd year, thus ensuring the transition into the upper cycle, finalized in year 5 with the granting of the title of engineer. For those who fail this validation, there is the possibility to be included in the 3rd year of the “professional license in the field of materials”. The direct course of material engineering can be done in several variants of specialization, such as: “material resources management”, “metallic materials development”, “metallic materials processing” or “materials science”.

2 - the professional license pathway in the field of materials. This will take place over a period of 3 years. Professionalization can be carried out in one of the domains specific to the engineering of metallic materials: metalworking, plastic deformation, thermal and surface treatments, welding of materials, casting of metallic materials, investigation and control of metallic materials, etc. After graduating, the graduates can carry out two types of action: the professional validation on the labor market or the continuation of studies at the level of the first pathway, after an admission exam. The framing will take place in the 3rd year of the direct engineering route.

3 - the pathway of university studies of materials technology. It will take place over a 2 years period. The training is done in certain particular fields of materials engineering and at the level of qualifications specific to the “higher education technician”. After the graduation exam, the graduates can carry out two types of action: the professional validation on the labor market or the admission to the professional license course, the matriculation being made in the 3rd year.

4 - the engineering specialization pathway. This will take place over the course of a year for engineer graduates in a particular field who want to become professional in a branch of “materials engineering” and acquire the title of engineer in the respective branch, for example: metal casting engineer, plastic deformation engineer, metal-working engineer, etc.

5 - the dual engineering pathway. This will be carried out, after obtaining the license, for a period of 3 years. The double specialization aims at the new fields that appear at the interface of several fields, such as: computer science applied in materials engineering, environmental protection and sustainable development in materials engineering, energy and exploitation of technology infrastructure specific to environmental engineering; integrated manufacturing management in materials engineering.
Figure 6. Defining elements for Materials engineering.

6 - the validation of knowledge pathway in the field of materials engineering. The course takes place according to the training of the applicants in 2 variants: the 2-year version for those who have university studies in adjacent fields to engineering (physics, chemistry, etc.) and at least 5 years experience in the field of desired attestation, and the one-year version for those who are in possession of an engineering degree and experience of at least 5 years in a field of materials engineering.

It is important that the engineer awarding title programs and structures are validated by the engineers’ professional structures, in this case the material engineers.

From the analysis it is estimated that the “material engineering” should not be overlapped with the “material science”, which must materialize at the three levels of engineering training: bachelor, master’s degree and Ph.D.

In engineering, the truth is designed, a process that takes into account the pragmatic goals to be achieved, the conditions in which they are carried out, and the processes and resources, regardless of their nature, that are made available. Considering the specific engineering mechanism of conception of
the “new”, in the current practices of various economic and social domains, at least at the level of technology, were adopted variants of engaging engineering in the appreciation of some activities.

Thus, specializations, such as: “financial engineering”, “social engineering experiments”, “professional training engineering”, “pedagogical engineering” etc. have emerged and consolidated, often with a pejorative sense.

![Organizational chart for the engineering route, license and specialization.](image)

**Figure 7.** Organizational chart for the engineering route, license and specialization.

At the level of science, truth is sought for a clearly defined situation where intuition or reasoning seeks to obtain the truth that is confirmed or not at the level of the experiment or a demonstration that is based on physical-mathematical tools. In this situation, the objectives are theoretical, and the finality, from the perspective of truth, is set between “right” and “wrong”. It is true that the results of this activity can represent the substantiation of engineering constructions, but it is not a strict result of an engineering activity.

From this presentation, we notice that there is a substantial distinction between the “science” and “engineering” of a domain. The areas most affected are “materials” or “environmental protection”.

Therefore, an approach of “materials engineering” on the principle of “materials science” is not beneficial to the beneficiaries of educational processes.

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