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Elements of the Anthropological Theory of Didactics in the Selection of Contents in a Course of Fluid Mechanics in Engineering

José Luis Díaz Palencia[1*], Antonio Naranjo Redondo[1], Pedro Vivas Caballero[1]

[1]Escuela Politécnica Superior, Universidad Francisco de Vitoria, Madrid, Spain
E-mail: Joseluis.diaz@ufv.es

Abstract - *The Anthropological Theory of Didactics has been applied to the field of didactics of mathematics with remarkable success. Fluid Mechanics is a discipline with a strong mathematical background, where mathematics is used for modeling the continuous environment. In addition, the Fluid Mechanics concepts are essential for the future engineer or scientist. For this reason, it is worth thinking whether the content that developed in engineering schools or science faculties are those demanded by the future professionals. The objective of this article is to know the institutional distance between the University and society as a demander of technologies based on Fluid Mechanics. To this end, the methodology based on the issuance of a questionnaire to experts focused on aspects such as present and emerging content associated with the Fluid Mechanics of an engineering degree is used. The results highlight the existence of an institutional distance between the University and the Enterprise (as a technology executor) in the conception of contents, thus establishing an area of potential improvement within the noosphere associated with fluid mechanics.*

Keywords – *Theory anthropology, didactics, noosphere, content, experts, questionnaire, distance, institutions.*

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1. Introduction

Fluid mechanics is a basic subject of notable relevance in technical or scientific degrees. In the training of the engineer, it is essential to successfully face future professional issues such as those related to the management and storage of the energy contained in a continuous fluid medium.

Fluid mechanics is a subject taught in the middle courses of technical or scientific degrees, which can be related to an increasingly established scientific maturity of students. Fluid mechanics begins, in the form of a requirement to be known, in the physical and mathematical sciences of the first courses of the degree. From these, a meeting point is configured that allows the extension of scientific reasoning. Key aspects are the understanding of the object to be studied as a continuous element existing in reality, the understanding of mathematics and physics, which support as pillars the exercise of conceptualisation and modeling, and the formation of a critical spirit in the interpretation of the result whose validity requires an exercise of calibration with the reality under study. From the scientific maturity provided by a fluid mechanics course, students acquire competences to study branches applied to their future field of specialisation within the degree: hydraulics, thermal engines, plasmas, aerodynamics, aeroelasticity, etc.

The relevance of the mathematical models of fluid mechanics is explained from their fields of application to the real phenomena they try to model. Freudenthal [8] introduced the concept of inversion and conversion to justify how a mathematical knowledge arising from real and tangible experience ends up becoming an increasingly condensed and abstract form, becoming a universal mathematical content. Fluid mechanics can be understood as a science arising from observation and experimentation (we remember the studies of Da Vinci, Galileo or Torricelli on experimental hydraulics) that at a given moment in time, begins an escalation towards the economy of the concept to form cognitive superstructures close to mathematics. In fact, one of the great mathematical challenges of our time, the solution of the Navier-Stokes equations, arises from the application of patterns of knowledge and reasoning typical of fluid mechanics. In this line of thought, the rigorous character of mathematics and the application bases of fluid mechanics are conceived as a unique symbiosis that allows the segregation between the theoretical and the applied fields. The conception of fluid mechanics as an applied and experimental mathematics is appropriate, since it makes it possible to give meaning to subjects such as differential calculus, algebra, differential equations or numerical calculus. Authors such as Harris, Black, Hernandez-Martínez, Pepin and Williams [9] emphasise how the integration of mathematics in the applied sciences prevents mathematics from being perceived as isolated from the scientific or technical field. The fact that fluid mechanics and mathematics share the principle of inversion and conversion as well as that both constitute a symbiotic front in engineering and science degrees, suggests the possibility of applying Chevallard's [2] anthropological theory of the didactic (ATD) which has been extensively treated for the field of mathematics didactics (also in its applied forms). Therefore, we have selected those authors and references that have emphasised the development of the ATD from an applied mathematics and we have looked for common points with the possibilities of encounter offered by fluid mechanics.

As has been exposed, the fact that mathematics is constituted as a substantial part of fluid mechanics, leads us to consider aspects such as the perception of students towards mathematics or the ability of teachers to value it in a context of application to an object of study of interest in the fields of technical and scientific training. Baquero, Bosch and Gascón [1] argue that, in the university institution, mathematics is constructed from a perspective far removed from the model or application potential. In this way, they argue that mathematics constitutes an autonomous formation erected as a self-sufficient science in spite of being institutionalised in the field of technical schools or faculties of applied sciences. In the present analysis, we try to build a framework of understanding about the relationship between fluid mechanics, which is taught in tertiary education, and the social environment, the institution and the teachers. From the theoretical scope provided by ATD, we employ tools and key elements of this theory with emphasis on the personal relationship of the teacher with fluid mechanics, the relationship of the institution with society and the teacher, and the identification of lines of didactic content demanded by society on the knowledge to be taught in fluid mechanics. We will observe how fluid mechanics is perceived from several points of view: a professional engineer without contact with the University, an engineer working as a professional in a company of the sector and as a part-time professor at the University, a professor and researcher with experience in a company and a professor and researcher with unique experience in the institution where he/she works. For each of the selected profiles, members of the group of experts in possession of the knowledge, a common questionnaire was carried out with the aim of studying the relationships and restrictions existing at the levels of society, University, pedagogy and discipline within the co-determination between fluid mechanics and didactics.

2. Theoretical Framework

The teaching and learning of fluid mechanics in tertiary studies has been linked to curricular criteria in relation to the institutional and degree levels to be taught. From the theory of didactic transposition, we start from the premise that any knowledge constituted as a discipline (such as fluid mechanics) is subject to an institutional superstructure. Let us think of two specific institutions, the University, as a reference center of knowledge and know-how, and the Company, as a competent area of applied knowledge and a place of transformation of knowledge into technology demanded by society. In both institutions, fluid mechanics develops and transforms over time. Certain notions about fluid mechanics, certain techniques or theories may remain unknown to one institution while they may be widely developed in another. This aspect may lead to an increase in the distance between the two institutions. We will refer to this concept as institutional distance or norm. The institutional distance between the University and the Company should be set at moderate values to ensure optimal functioning of the noosphere associated with fluid mechanics. This would ensure an optimal understanding between institutions as generators of knowledge and potential applications in the discipline in question. However, an analysis of the current situation is necessary to address and understand the state of the institutional distance, with the intention of identifying potential areas for improvement in the contents of fluid mechanics taught in technical schools.

Our objective requires a multidimensional approach that highlights all the agents that make up the implementation of the teaching exercise in fluid mechanics. Consequently, we apply the ideas of Chevallard's Anthropological Theory of Didactics (hereafter ATD) [4]. The ATD has been widely used for the analysis in the didactics of mathematics, from different prisms, one of them focused on the elaboration of typical models of science [1]. Thus, we accept fluid mechanics as a knowledge with a high mathematical content oriented to the modeling of continuous mass systems. Gascón [11] established, as a constructivist genesis of mathematical knowledge, an effort focused on the modeling of a reality on which such knowledge operates. In this way, we provide the didactics of mathematics and fluid mechanics with a common thread where the general ideas of ATD have a place, allowing a controlled extension from the field of didactics of mathematics to the field of didactics of fluid mechanics. Along the same lines, it is necessary to emphasise that throughout this paper the problem of mathematical modeling is presented as an essential element of fluid mechanics. Modeling is the transforming attitude that allows the rigorous expression of human thought in order to broaden the vision of the observed reality. The approach to the reality of fluid mechanics, as a science, emanates from the current paradigm of the physical sciences, so that its implementation must be systematically supported by mathematical laws. Fluid mechanics enables mathematics with a functional vision, beyond the formal aspects, allowing a vision close to the questioning of the world, away from the monumentalist study of the concepts, as if they were works of a museum to be explained and admired.

The vision of the different paths of study and research [7] that emerge from fluid mechanics constitute a corpus of action on which to develop the perspective of analytical thinking, operation and change that properly configure the engineer and his work [10].

The ATD formulates that an Institution *I* is a social organisation constituted by members over which *I* establishes a concrete way of doing and thinking [6]. Each member of an Institution *I* carries out its activity in terms of one or more praxeologies. These praxeologies refer to the type of tasks to be performed by a member of a given institution using specific techniques. In addition, the technological discourse associated with each specific technique makes it possible to justify why a particular technique is used and not another. The type of tasks, as well as their techniques, based on a technological discourse specific to Institution *I*, has a direct impact on the behaviour of each member of Institution *I*. It is relevant to highlight that, according to ATD, a change in the technological paradigm of a given institution entails a change in the discourse justifying its techniques, and therefore, a potential modification of these, impacting on the praxeology of each member of the institution.

Fluid mechanics is a science in its own right, with its own characteristic lines of research, specialised journals and areas of training and doctoral research. Along the lines of Chevallard [3], we can distinguish three fundamental activities that make it possible to explain, at a high level, the interrelationships between the learned knowledge of fluid mechanics and the knowledge to be taught in institutions, namely: Study process, thematic organisation and didactic organisation. Moreover, Chevallard [5] himself establishes an isomorphism between the thematic aspects and didactic organisation by proposing a hierarchy or dimension of study to carry out the association between theme and didactics (Figure 1).

Focusing attention on the social hierarchy, it becomes relevant to understand how the stakeholders that are part of society, as demanders of knowledge, influence the thematic and didactic organisation. Moreover, this demand permeates lower hierarchies, giving them meaning and structure.

The research presented aims at analysing the opinions of a group of experts representative of the noosphere on fluid mechanics. Each expert is defined as a person *e* occupying a position *p* within an institution *Ii* (where the index i indicates each of the different institutions to which the surveyed expert belongs or has belonged). In our case, we will consider two key institutions: institution *I1* which represents the aerospace engineering training school and institution *I2* which represents an aerospace company of recognised prestige where future graduates can work and which is based in different European countries. Within the institution *I1* there are different positions related too teaching and research, typical of any university institution. Within the *I2* institution, a sample of fluid dynamic engineers have been selected to design, integrate and certify aeronautical systems based on the use of a fluid: specifically fuel, hydraulic and air systems.

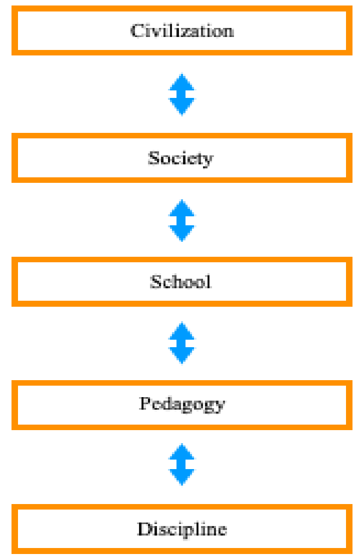

Figure 1. Levels of isomorphism to carry out the association between thematics and didactics

The type of tasks to be carried out, as well as their techniques and their justification or technological discourse are different for each of the positions available in each of the institutions. Moreover, it may be the case that the same expert holds a position in institution *I2* and holds another position in institution *I1* as an associate professor or has left his position in I2 to become a full-time professor in *I1*. The interrelationships between the different positions of the same expert are interesting as they define hybrid praxeologies of their own between two different institutions. We postulate that the techniques and justificatory discourses among hybrid experts with experience at both institutions (*I1* and *I2*) will be different with respect to an expert who only knows *I1* or *I2*. These possible interrelationships lead us to the concept of personal relationship. To represent this concept, let us first define an object as a delimited entity in the environment that constitutes a target of knowledge and/or attention for the expert. Contextually, in *I1* we can consider as an object the preparation of the contents of a class or the teaching methodology. Similarly, in *I2* we can define an object as the design and sizing of a fluid network or the preparation of a technical document. For whatever the object is in institution *I1* (which we will call *O1*) and in institution *I2* (*O2*), the personal relationship (*Pr*) of each expert with the object in question is defined.

The construction of the personal relations with the object depends on the institution in which the expert is located. For the same object, say calculation of head loss in a facility, the institution *I1* imposes a strategy related to teaching and/or research, being, consequently, the personal relationship of the expert centred on both aspects. However, an expert in institution *I2* will face the pressure drop problem using an approach that allows him to reduce the execution time and costs that act as constraints on his work. The construction of the personal relationship is particularly relevant in the case of the expert who has a synchronous or asynchronous relationship with institutions *I1* and *I2*. During the research process we will note how this personal relationship is constructed and how it influences the praxeological conceptions of each institution. Trying to generalise, each expert *e* develops a personal experience in relation to the object *O* that can be summarised in an expression of the form:

$$Re\ (p1, p2, O) \tag{1}$$

where e = 1, 2... indicates the numbered expert, *p1* is the position of expert *e* in *I1* and *p2* indicates the position of expert *e* in *I2*. In the same way, the following personal relationships can be defined:

$$Re\ (p1, O) \tag{2}$$
$$Re\ (p2, O) \tag{3}$$

Throughout our research, it is observed how once the same object (i.e. present and future of the contents of fluid mechanics at university level) is identified, the approach towards it differs among the experts in relation to the positions (*p1, p2*) they occupy or have occupied in the institutions *I1, I2*.

3. Methodology

The objective of our research focuses on the present and emerging contents of a fluid mechanics course at university level. In addition, we delve into the knowledge of the current state of the representative noosphere of the learning-teaching binomial of fluid mechanics. To this end, different profiles of experts with different personal relationships are analysed. Specifically, the historical profile of each expert is classified according to the following aspects:

- Professional profile
- Research profile
- Years of seniority in your work
- Current and past positions in the business sector
- Current and past positions in the education sector

A total of seven experts were interviewed. Four of the experts are currently working as professors and researchers in fluid mechanics at a public university technical college. All four experts have more than 400 hours of teaching experience in fluid mechanics and engineering. In addition, they have published more than twenty articles in specialised journals, with an average publication rate of 36 articles in journals of impact. It is worth mentioning the notoriety of one of the experts, who has been awarded the Prince of Asturias Prize for Scientific and Technical Research. It is, therefore, a group of extraordinary expertise in fluid mechanics at university level. On the other hand, the remaining three of the seven experts interviewed are engineers who carry out their professional work in the company where they have developed fluid-related systems in military and civil aircraft. One of the three experts related to the company has research and teaching activities with the university as an associate professor in fluid mechanics.

Before conducting the interviews, each of the experts surveyed was asked to submit an summarised curriculum vitae, paying attention to the following aspects:

- Bachelor's Degree or Engineering
- Master's degree (if any)
- Doctorate (if any)
- Main Occupation
- Collaborations with public or private companies
- Collaborations with the University

with the aim of pointing out those aspects related to the institutions *I1, I2* and the respective positions *p1, p2* that allow us to highlight the differences in the personal relationships of each of the experts with fluid mechanics.

The information extracted from the curriculum vitae of each of the experts is summarised below:

Expert 1 (E1):

Expert *E1* has an in-depth training in fluid mechanics. His lines of research are focused on the fields of combustion, fluid mechanics and numerical methods. He has also collaborated with companies in which he has carried out studies of different nature related to fluid mechanics. He is the manager of a company dedicated to thermal engineering modeling. His current position is as a Full Time Professor at the University. In brief:

- Aeronautical Engineer
- PhD in Aeronautical Engineering
- University Professor
- He has carried out studies with public and private sector companies in thermal modeling. In addition, he supports a company dedicated to fluid modeling.

Therefore, the personal relationship of the expert *E1* is built from his historical profile and from the positions *p1* (Full Time University Professor) and *p2* (Manager of a company).

Experts 2 (E2), 3 (E3) and 4 (E4):

Experts *E2, E3* and *E4* can be considered as a scientific reference in fluid mechanics. Their lines of research focus on the fields of combustion, jet dynamics and semiconductor materials. These profiles are almost exclusively oriented to the academic field with some sporadic collaboration with the company in the form of subsidised projects. All three experts are university professors. In brief:

- Aeronautical engineers
- Doctors Aeronautical engineers
- University professors
- Their studies are almost exclusively related to the academic field, with the exception of some minor collaboration with the business sector.

The personal relationship of experts *E2, E3* and *E4* can be constructed from the academic perspective and from position *p1* (University Professor).

Expert 5 (E5):

Expert *E5* has aeronautical engineering as his basic training, he also has a PhD in science and technology. He is currently working in the private sector as a fluid modeling and simulation engineer. He has worked in the design of aeronautical systems in a leading company in the aerospace sector. In addition, he practices as an associate professor of fluid mechanics and mathematics. In brief:

- Aeronautical engineer
- Doctorate of Science in Technology
- Fluid modeling and simulation engineer
- He carries out his professional work in the company while working as an associate professor at the University.

The personal relationship of expert *E5* is particularly interesting. We can observe that he presents a vision of fluid mechanics from the professional and applied perspective in the company and from the University, where he develops his work collaborating with the fluid mechanics department. His personal relationship is built, therefore, from the academic focus with position *p1* (University associate professor) and from position *p2* (Fluid modeling engineer).

Experts 6 (E6) and 7 (E7):

Experts *E6* and *E7* have aeronautical engineering as their basic training. Since the completion of their studies, they have not been in contact with the academic field, developing their work exclusively in the company as fluid systems design engineers in aircraft. Their trajectory can be summarised as follows:

- Aeronautical engineers
- Fluid systems design engineers
- They work exclusively in-house

The personal relationship of experts *E6* and *E7* towards fluid mechanics is built from position *p2* (Fluid systems design engineers).

Each of the aforementioned experts was surveyed with the aim of bringing out the personal relationships of each of them towards the contents of fluid mechanics by emphasising the existence of divergent elements among the experts that may explain their different conceptions towards what should be considered as knowledge to be taught in a fluid mechanics course. The questions followed the following sequence:

Question 1 (Q1): Which topics do you think should be studied in a Fluid Mechanics course?

Question 2 (Q2): Why those specific topics?

Question 3 (Q3): If you had the opportunity to add any content to a Fluid Mechanics course, what would it be and why?

Question 4 (Q4): Which teaching methodology do you consider as the most appropriate for the development of a Fluid Mechanics course?

Question 5 (Q5): What difficulties have you encountered with students coming to a fluid mechanics course? In your opinion, what are they due to?

In the present research we will focus on an analysis of the contents of a fluid mechanics course, so that our objective will be the answers to questions *Q1, Q2* and *Q3*, leaving the analysis of questions *Q4* and *Q5* for further research focused on the forms and methodologies of teaching and learning.

4. Analysis of the data obtained from the survey

Each of the questions and the answers of each of the experts surveyed are presented below with a comparative analysis.

Question 1 (Q1): Which topics do you think should be studied in a Fluid Mechanics course?

Answer E1: Those taught in the School (of Engineering), in principle. But I would put more emphasis on the estimation of orders of magnitude and dimensional analysis, since they are given too much on top and they are two very powerful tools.

The contents taught at the School (meaning engineering education) are detailed in the answer of the expert *E2* with whom *E1* shares a subject.

Answer E2: Macroscopic variables. Local thermodynamic equilibrium and hydrodynamic equations. Conservation equations. Equations of state. Transport phenomena. Fluid statics. Unidirectional and quasi-unidirectional motions. Dimensional analysis. Movements at low Reynolds numbers. Hydrodynamic lubrication. High Reynolds number motions. Euler equations and discontinuity layers. Boundary layer. Laminar boundary layer equations and characteristics. Detachment. Thermal boundary layer. Transition and turbulent boundary layer. Turbulence. Energy scales and cascade. Free turbulent flows with shear. Turbulent flows limited by walls.

The answers of experts *E3* and *E4* are exactly the same as the answers of expert *E2*. Note that all three experts have configured the fluid mechanics subject during a joint work. We observe here the construction of a content that lasts over time and subject to the principle of teaching economy.

Answer E5: Equations of conservation of mass, energy and momentum. Numerical analysis of the most important equations. Fluid statics. Motion in pipes, pumps, turbines and compressors. Dimensional analysis. Fluid regimes. Transient motion. Turbulence.

Answer E6: Bernoulli's equation. Pressure drops in pipes. Pumps, turbines and compressors. Transient flow. Equation of motion. Energy equation. Dimensional analysis. Regimes of a fluid.

Answer E7: Types of currents. Reynolds number. Energy equation and conservation laws. Turbomachine's and design of pressure systems. Dimensional analysis. Liquid Hammering.

First, we can compare the answers given by the experts with an academic background (experts *E1, E2, E3* and *E4*). As can be seen, these experts share their opinion on what should be taught in a fluid mechanics course. Expert *E1*, in addition, stresses the importance of studying in some detail the elements related to dimensional analysis and orders of magnitude for their computational power. Dimensional analysis is considered by all the experts surveyed as an appropriate subject. Regarding the answers given by the experts with experience in companies of the sector (*E5, E6* and *E7*) we observe that the three cases maintain as relevant the equations of conservation and motion, introduce the study of transient motion and give relevance to applications related to pressure drops, pumps, turbines and compressors. It is noteworthy that expert *E5* also introduces a topic related to the numerical analysis of equations and introduces a topic on fluid statics. In turn, we can compare the answers of experts *E1, E2, E3* and *E4* with those offered by experts *E5, E6* and *E7*, which, in turn, allows us to relate and compare the vision of two institutions *I1* (represented by *E1, E2, E3* and *E4*) and *I2* (represented by *E5, E6* and *E7*). The praxeology imposed on its experts by institution *I2* suggests the need to have a solid base in those more applied aspects related to calculations of fluid systems (pipes, pumps, compressors and turbines) based on simple numerical or analytical analysis by means of dimensional analysis. In addition, the requirement of *I2*, not contemplated in *I1*, towards the study of transient phenomena in fluids is highlighted, since situations such as liquid hammering can cause irreversible damage to an installation. At the same time, expert *E7* suggests the need to introduce aspects related to the design of pressure systems and turbomachinery. We also note that expert *E5*, who has a relationship as an associate professor with the institution *I1*, establishes common thematic areas with the answers given by the members of *I1* in terms of fluid statics, turbulence or dimensional analysis.

Question 2 (Q2): Why these specific topics?

The answers to question *Q2* can be summarised as follows:

Answer E1: Because of the above.

The answer of experts *E2, E3* and *E4* was agreed among the three experts and was sent as a single common answer.

Answer E2, E3 and E4: The first two topics constitute the general formulation of fluid mechanics. The third topic and part of the fourth serve to become familiar with the handling of the equations in simple cases. The fourth topic also includes problems of practical interest, particularly if complemented with the hydraulic approximation for turbulent flows, although formally turbulence is studied in the last topic. The fifth topic is the study of the simplification of fluid mechanics problems by exploiting their invariance to changes in unit systems. The sixth topic is a study of some characteristics of flows with negligible inertial effects. The seventh and eighth topics are the study of flow characteristics at high Reynolds numbers, both for liquids and gases. They are essential for aeronautical applications and are the point of connection with aerodynamics. The eighth topic is also the point of connection with a more detailed study of heat transfer problems. The last topic is the study of turbulent flows. Some parts may preempt other topics.

Answer E5: In my opinion the contents are appropriate, although I consider that more relevance should be given to fluid statics to know how to calculate pressure distributions in a fluid, too dimensional analysis for its simplicity and power. On the other hand, I consider that every fluid or hydraulic engineer should know how to properly design pressure drops and diameters in pipes. I consider that this part is not treated too much in fluid mechanics curricula.

Answer E6: I believe that a fluid mechanics course should emphasise those concepts that will be useful for their future as engineers. Bernoulli's equation is basic and simple. It allows you to understand and calculate pressure drops and to analyze all types of turbomachinery. I think it is very important that this equation is treated well and with plenty of time to understand the concepts. Because of its simplicity, Bernoulli's equation is widely used in the company. There is no technical meeting that does not end up talking about Bernoulli's equation. In addition, I consider it very important to emphasise transient flow in order to properly calculate liquid hammering. I believe that this part is sometimes undervalued in fluid mechanics courses, but the truth is that knowing how to calculate transients in a pipe line is not easy. The equations of motion and energy should be studied for their possible use for numerical integration, but, above all, as a basis for *dimensional analysis, which is also very important, since it allows preliminary analysis of solutions. In the early design phases, these preliminary analyses are of great value. Finally, I believe that time should be invested in explaining well the regimes of a fluid (laminar, turbulent and mixed) since for an engineer it can mean a saving or an important cost in the installation depending on the fluid regime.*

Answer E7: Every engineer should know the most important applications of fluid mechanics.

On this occasion, the noosphere of the educational system in fluid mechanics suggests that there are two ways of dealing with the subject matter institutionalised through *I1* and *I2*. In both cases, common areas are observed (conservation equations and dimensional analysis mainly), however, the *I2* institution demands to deal with topics related to transient phenomena and greater applications to fluid systems. *I2* experts justify their choice of contents by the fact that every professional engineer should have a deep knowledge of his profession and, therefore, attention should be paid to those basic contents whose reinforcement will have an impact on a more qualified professional. However, the experts of the institution *I1* have established a reasonable and guided guideline towards the broad problem of fluid mechanics, trying to find a common thread that generates and gives meaning to the contents.

Question 3 (Q3): If you had the opportunity to add any content to a fluid mechanics course, what would it be and why?

Let's look at each of the answers again:

Answer E1: I would add an extensive topic devoted to estimating orders of magnitude. It is something that students have a hard time understanding and using, and yet it is something very simple and logical that has very high analytical power.

Answer E2: Numerical calculation. Commercial codes and specific methods for potential flows, vorticity dynamics and boundary layer. The reason is the obvious practical importance of numerical computation in fluid mechanics. Microfluidics. This is a broad topic of current interest, although it may be somewhat removed from aeronautical applications.

The answers of experts *E3* and *E4* were previously agreed between them so that they were sent jointly.

Responses E3 and E4: I think it would be essential to dedicate an extensive topic to modeling. I think that students should know how to make a model and, immediately after, know the mathematical tools that fluid mechanics provides for its resolution. Students who come to the company do not fully understand that they are the ones who generate the model to be solved based on an understanding of reality. Normally, they think that in their professional work the models are given to them because they are used to being given them already made in engineering schools, when the truth is that they themselves are the ones who, in the future, must extract the model. For this reason, I think it is important to model more.

Answer E5: I would give them an introduction to fluid mechanics models as a basis for the mathematical activity they will develop in the course.

Answer E6: I think I would introduce turbulence phenomena in pipes and a chapter on design and modeling.

Answer E7: A topic on real experiences in the design and modeling of fluid systems would be useful, for example, they could learn how an oil-hydraulic network has been designed.

In the answers to question *Q3* we observe that there is consensus on the need to introduce more content on modeling and design of fluid components. Of particular interest is the response of experts *E3* and *E4*. Both experts argue that the future graduates undertake their professional activity without having any indication of how to model, in addition, the common value highlighted by the experts *E5, E6* and *E7* members of the institution *I2*. We observe, once again, the existence of an institutional distance around phenomena related to the construction of fluid mechanics knowledge. On this occasion, the noosphere claims a construction of knowledge based on the model and its conception.

5. Conclusions and Future Lines

During the development of the present work, the existence of an institutional distance between the University or institution *I1* and the company or institution *I2* regarding the contents that a fluid mechanics course should contain has become evident. Each of the experts surveyed have highlighted the different needs of the members of the noosphere regarding fluid mechanics. There are points of agreement between the experts of each institution regarding the contents of conservation equations and dimensional analysis due to their computational power and ability to approach highly complex problems. In addition, the survey reveals important differences between the institutions regarding the contents that should be taught in a fluid mechanics course. Specifically, *I2* experts suggest the importance of teaching contents related to transient phenomena (or, informally, Liquid Hammering), turbomachinery and system design. Expert *E5*, who has a relationship with both institutions, suggests meeting points around fluid statics, turbulence or dimensional analysis. In conclusion, the pressure of the noosphere of fluid mechanics around the institution *I1* as an agglutination of wise knowledge, suggests an update of contents in the subjects of fluid mechanics in engineering schools, especially, with the introduction of a subject on transient movements of fluids, pressure drops and relations between turbomachinery and the design of hydraulic systems. In addition, the need to introduce new concepts and contents about modeling in fluid mechanics and design phenomena that establish the guidelines for the future professional is highlighted. In the line of professional conception, a notable difference in the way of elaborating the contents has been observed among the experts. Thus, the experts of the *I2* institution have given greater importance to important contents for the future engineering professional, while the experts of *I1* elaborate the contents by means of a logical and reasonable thread based on wise knowledge.

Among the future lines of work, it is important to systematically present the results to questions *Q5* and *Q6*.

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