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CAN VALUES AND ATTITUDES IN ENGINEERING EDUCATION BE REGARDED AS UNCHANGING MATTERS?

MÓNICA BLANCO*

* Escola Superior d'Agricultura de Barcelona (ESAB)
Universitat Politècnica de Catalunya
Campus Baix Llobregat, 08860 Castelldefels (Barcelona), Spain
e-mail: monica.blanco@upc.edu

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Summary. Sylvestre François Lacroix (1765-1843) composed textbooks in mathematics that turned out to be highly popular and influential over a period of fifty years. In fact with his work Lacroix contributed to the establishment of mathematics instruction in the new public system of education in France. Ranging over practically all branches of school mathematics, his textbooks were addressed to students of all degrees of mathematics instruction, and specifically, to engineers-to-be. In 1816 he wrote the volume *Essais sur l'enseignement en général, et sur celui des mathématiques en particulier, ou Manière d'étudier et d'enseigner les Mathématiques*. This work gathered Lacroix's reflections on the education of sciences, in general, and of mathematics, in particular. The aim of this paper is to analyze some values and attitudes in education highlighted by Lacroix in his *Essais*. The discussion of some excerpts from this work reveals that Lacroix regarded as a fundamental component in the education of sciences and mathematics the transmission of values such as the search for the truth beyond prejudices, communication skills, collaborative work and lifelong learning, among others. Hence, Lacroix's text, written nearly two centuries ago, displays values in engineering education that still hold today.

1 INTRODUCTION

It goes without saying that mathematics plays a fundamental role in the education of engineering students. The ability to assess the power and usefulness of mathematical tools allows to understand the scientific-technological environment that surrounds us. The learning of mathematical topics instigates students to exercise their ability to make well grounded decisions, to state interpretations with critical awareness, to develop his analytical thinking, and to communicate with scientific rigor. To sum up, the learning of mathematics supplies students with the values and attitudes necessary to fully perform their role of citizens, not only professionally, but also socially.

Yet it is quite natural to wonder whether changes in society and in the conception of "profession" may prompt changes in values in engineering education. Questions about the beliefs and intentions of the "actors" involved in education turn out to be a new approach in the history of mathematics education. Since the production of textbooks seems to be subject

to social and institutional constraints, it is most valuable to consider the social and cultural context of their utilization[4,5].

Therefore the values and attitudes transmitted in education can also be regarded as a fundamental aspect in the analysis of mathematics textbooks. The aim of this paper is to analyze some values and attitudes in engineering education from a historical perspective through the discussion of a methodological handbook on mathematics instruction.

2 LACROIX'S ROLE IN ENGINEERING EDUCATION

Several educational systems coexisted in eighteenth-century France. Before the Revolution, university education was mainly restricted to the *collèges*, run by religious orders, where mathematics was taught at a rather elementary level. By the 1750s, however, a well-developed network of *écoles militaires* had been established, which made the functions of the universities obsolete. Mathematics became a leading discipline within this context, reaching its highest level at the *École du Génie* in Mézières, the school founded in 1748 for training military engineers[6]. After the Revolution, another educational system emerged. Among the revolutionary reforms it stands out the establishment of the *École Polytechnique* in 1794, succeeding the system of engineering schools of the *Ancien Régime*[1,6]. To ensure the uniform application of "the good method," the educational reformers insisted on the elaboration of "the good textbook" – one per discipline - prescribed by a comission set up by central state authorities[4,5].

Sylvestre François Lacroix (1765-1843) was a member of the comission for the first *concours* of 1794. A former teacher of mathematics during the last years of the *Ancien Régime*, particularly in military schools, after the Revolution Lacroix contributed actively to the establishment of a general system of instruction in France, in which mathematics was considered to be an integral part of general instruction. Lacroix taught mathematics at almost all the important Parisian institutions: *École Normale*, the *École Centrale* (*des Quatre Nations*), the *Lycée*, the *École Polytechnique*, the *Faculté des Sciences*, and the *Collège de France*. Over the period 1795-1845 he composed textbooks for practically all branches of school mathematics and for all degrees of mathematics instruction, from secondary to higher and technical education (excluding primary education). His textbook series was highly influential, as the large numbers per edition, new editions and translations seem to suggest - this turned out to be particularly relevant in the case of the calculus[2]. To the extent that his textbooks were adopted exclusively for the *Lycées* in the commission of 1803.

Lacroix aimed to develop a coherent corpus of school mathematics, from secondary to higher education. His textbooks can be regarded as representatives of the so-called *livres élémentaires*, basic textbooks for the general educational system. Besides assembling the original results of various researchers, they also *elementarized* and supplied structure to the broad range of topics contained in Lacroix's textbooks. The main title of his *œuvre*, *Cours complet de mathématiques*, expressed this "universal" approach. An element of this complete textbook series is his methodological handbook *Essais sur l'Enseignement en général, et sur*

celui des Mathématiques en particulier, ou Manière d'étudier et d'enseigner les Mathématiques (1816)[3], gathering Lacroix's reflections on the education of sciences in general, and mathematics in particular. The aim of this paper is to discuss some excerpts of this work, concerning values and attitudes to be taken into account when teaching mathematics, in particular. Given Lacroix's close connection with the engineering education, I deem it worth discussing this work of Lacroix in the context of education in values in engineering.

3 VALUES AND ATTITUDES IN THE *ESSAIS SUR L'ENSEIGNEMENT...*

The *Essais sur l'Enseignement* opens with the section *De la culture des Mathématiques pendant le dix-huitième siècle, et de leur influence sur la marche de l'esprit humain dans cet intervalle*. Such title suggested me that this section could give a glimpse of some values and attitudes concerning the engineering education at the time. Throughout this introductory section, Lacroix conveyed the idea that the transmission of values such as the search for the truth beyond prejudices, with the aid of logical reasoning, played a crucial role in the education of sciences and mathematics:

> Recueillir des faits, en déduire des résultats, les appliquer aux circonstances où ils doivent se reproduire: voilà la marche que doit suivre notre esprit pour arriver à la vérité...[*]

> Le goût de l'exactitude, l'impossibilité de se contenter de notions vagues, de s'attacher à des hypothèses, quelque séduisantes qu'elles fussent, le besoin d'appercevoir clairement la liaison des propositions et le but où elles tendent, fruits les plus précieux de l'étude des Mathématiques...[†]

Of the eighteenth century Lacroix praised the inclination towards questioning, surveying, calculating, and observing, as opposite to prejudices, ignorance and religious fanaticism, which undoubtedly hamper progress. Likewise, he warned against fallacious arguments and hasty conclusions. For the sake of the society, truth must prevail, as Lacroix claimed in the following passage:

> Le savant doit sans cesse s'attacher aux recherches qui peuvent être utiles, ou parcequ'elles donnent de nouveaux résultats applicables aux arts de la société, ou parcequ'en dévoilant à nos yeux les véritables lis de la nature, en éclairant notre esprit sur ce qui est et sur ce qui ne saurait exister, elles dissipent les préjugés, qui ne cèdent une partie de leur empire que pour en acquérir une autre;...[‡]

[*] "To collect facts, to infer some results from them, to apply them to the circunstances under which they take place: that is the way our mind must follow to reach the truth" (Lacroix 1838, p. 10).

[†] "A liking for exactness, the impossibility of contenting oneself with vagues notions, of attaching to hypotheses, however attractive they are, the need of becoming aware of the link between propositions and the goal they search for, the most precious fruits in the study of Mathematics" (Lacroix 1838, p. 24).

[‡] "The *savant* must constantly cling to that research that may turn out to be useful, either because it provides new results that can be applied to the arts of society, or because by uncovering the true lily of nature to us, by enlighting our mind on what is and what could not exist, it dispels prejudices, which do not give up a single part of they empire but to acquire another one" (Lacroix 1838, p. 41).

In fact, in the second section, *Sur la manière de les enseigner, et d'apprécier, dans les examens, le savoir de ceux qui les ont étudiées*, Lacroix introduced his perception of the role of the individual in attaining the benefit of the society:

> Tout homme qui veut rendre son existence utile à la société, doit marcher constamment vers un même but; ce n'est que par une continuité d'efforts dirigés toujours dans le même sens, qu'il peut atteindre à de véritables succès, et acquérir quelques droits à l'estime de ses contemporains et à la reconnaissance de ceux qui viendront après lui.[§]

The connection with one's contemporaries appears to be a relevant aspect in Lacroix's handbook at two levels. On the one hand, Lacroix stressed the importance of collaborative work, that is to say, the combination of individual efforts to increase the shared outcome:

> ..., c'était augmenter l'intensité de ce foyer de lumières, en multipliant d'une part les efforts et de l'autre l'attention; c'était faire contracter aux jeunes gens des liens d'amitié qui devaient par la suite produire l'union des corps où ils allaient entrer, et assurer leur concours pour le bien public, en faisant cesser les prétentions et les jalousies qui ne se sont manifestées que trop souvent; c'était intéresser à la gloire et aux succès de ces mêmes corps, les hommes qui dans les sciences fixaient les regardes de l'Europe éclairée.[**]

On the other hand, living in society clearly entails the interaction of individuals and, consequently, the communication between them. Lacroix was really concerned about the development of the student's communication skills, as he pointed out in the following passages:

> Mais quand il serait vrai que la culture des sciences aurait rendu plus rares les grands écrivains, n'a-t-elle pas multiplié les hommes capables d'exprimer avec netteté et précision des idées justes, et de communiquer facilement aux autres ce qu'ils ont appris, ce qu'ils ont imaginé.[††]

> Découvrir la vérité et la transmettre aux autres, voilà le but commun de leurs travaux.[‡‡]

> ... la facilité que peut avoir l'élève à s'énoncer, facilité qu'il est cependant nécessaire d'exercer et d'encourager, parqu'elle est utile dans presque tous les instans de la vie, et qu'elle est indispensable pour

[§] "Every man who wants to render his existence useful for the society must lead constantly to the same target; it is only by a continuity of efforts always directed towards the same direction, that he can attain true success, and obtain some rights in the eyes of his contemporaries and the acknowledgement of those who will come after him" (Lacroix 1838, p. 191).

[**] "..., it was to increase the intensity of this focus of enlightenment, by multiplying efforts, on the one hand, and attention, on the other; it was to make youths form ties of friendship that afterwards had to cause the association of the bodies they were going to enter, and to ensure their *concours* for the public good, by bringing conceit and envy to an end, which are to be found only too often; it was to get them interested in the glory and success of these bodies, the men who in sciences focused on the enlightened Europe" (Lacroix 1838, p. 34).

[††] "But when it would be true that scientific culture could have reduced the number of great writers, hasn't it multiplied the number of men able to utter fair ideas with clearness and precision, and to communicate with ease to others what they have learnt, what they have thought up" (Lacroix 1838, pp. 39-40).

[‡‡] "To uncover the truth and to communicate it to others, that is the shared goal of their works" (Lacroix 1838, p. 40).

> des hommes qui auront un jour des projets à présenter ou à discuter en présence de leurs camarades ou de leurs supérieurs.[§§]

Besides the explicit reasons given by Lacroix, the stress on communication skills could fit into a recent programmatic proposal in the study of the history of science, opened up by J. Secord. Secord's main point is the conceptualization of science as a form of communication. Insofar as communication contributed to the formulation of the final discourse of scientific disciplines, it cannot be considered to be a neutral process.[7]

From Lacroix's text it can be inferred that scientific education is a social process. However, Lacroix believed that the educational system should also focus on the development of indivual values, like life-long learning and self-teaching:

> ... il y un âge où l'homme ne peut plus s'instuire que par lui-même, et c'est à rendre cet âge le plus précoce qu'il est possible, que doit tendre l'éducation.[***]

To conclude, it is worth quoting Lacroix on the usefulness of the physic astronomy as seen by Laplace in his *Exposition du Système du Monde*:

> Conservons avec soin, augmentons le dépôt de ces hautes connaissances, les délices des êtres pensans. Elles ont rendu d'importans services à l'agriculture, à la navigation, à la géographie; mais leur plus grand bienfait est d'avoir dissipé les craintes occasionnées par les phénomènes célestes, et détruit les erreurs nées de l'ignorance de nos vrais rapports avec la nature, erreurs d'autant plus funestes que l'ordre social doit reposer sur ces rapports. VÉRITÉ, JUSTICE: voilà ses lois immuables. Loin de nous, la dangereuse maxime, qu'il est quelquefois utile de s'en écarter, et de tromper ou d'asservir les hommes, pour assurer leur bonheur: de fatales expériences ont prouvé dans tous les tems, que ces lois sacrées ne sont jamais impunément enfreintes.[†††]

In short, as far as Lacroix is concerned, truth and justice can be regarded as unchanging matters.

[§§] "... the fluency a pupil may have to express himself, fluency that is notwithstanding necessary to practice and encourage, because it is useful at nearly every moment in life, and which is essential for those who some day will have to present or discuss some project in front of their mates or their superiors" (Lacroix 1838, p. 229).

[***] "... there is an age when a man cannot be educated anymore but by himself, and it is to render this age as precocious as possible, that the education has to strive for" (Lacroix 1838, p. 223).

[†††] "Let us preserve with care, let us increase the amount of this high knowledge, the delights of the thinking beings. They have offered important services to agriculture, to navigation, to geography; but their greatest service is to have dispelled the fears caused by celestial phenomena, and to have erased the mistakes originated from the ignorance of our true connections with nature, mistakes all the more fatal since social order must rest on these connections. TRUTH, JUSTICE: those are its unchanging laws. Far from us, the dangerous maxim, that it is some times useful to move away from them, and to deceive or to enslave men, to ensure their happiness: fatal experiences have always proved that these sacred laws have never been infringed with impunity" (Lacroix 1838, pp. 43-44).

4 CONCLUSIONS

This paper approaches the topic of education in values from a historical perspective. In this framework, the figure of Lacroix represents a cornerstone in the sense that the remarkable success and diffusion of his mathematics textbooks helped in spreading values and attitudes in education, in particular in the engineering field.

The discussion of some excerpts from the handbook *Essais sur l'Enseignement...* reveals that Lacroix regarded as a fundamental component in the education of sciences and mathematics the transmission of values such as the search for the truth beyond prejudices, communication skills, collaborative work and lifelong learning, among others. Hence, Lacroix's text, written nearly two centuries ago, displays values in engineering education that still hold today. For instance, some of the above enumerated values are contained in the programme of the new European higher education context.

This is just a brief sketch of some values and attitudes that I made out in Lacroix's handbook. Yet, it contains more reflections on the learning-teaching process that deserve a closer study.

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