Women students at France's fourth largest engineering college (UTBM, 1985–2016): between *epiklerate*, maternal transmission, and modernity

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Introduction

Engineering colleges feature among the latest institutions to be studied in "gender and science". They stand as a major reconfiguration of the "territorial discrimination" that Margaret Rossiter identified for the American scientific world (Rossiter 1982). This is especially so in the case of France, where an age-old tradition of centralized and militarized state-sponsored *grandes écoles* (top-rank colleges) has long nurtured a very male-dominated core of engineering culture. The question of the cultural and social "passport" (Oldenziel, Canel and Zachmann, 2000: 1) needed to join this world of men arises then. The issue is particularly prominent in the French case, even after 1945 when female vocations in technology were encouraged by the advent of mixed secondary schooling (1957) and the roll-out of a policy favoring women in science and engineering, not to mention the emergence of new industries. The creation of new colleges which, like the UTBM studied here, were more democratic in terms of entrance requirements and open to women from the outset, also contributed to this movement. Lastly, after 1945 and even more so after 1968, French women called for greater educational and occupational equality. This contrasted with the pioneering generations of the 1920s who sought to promote technological education specifically for women and female employment in niche jobs (Canel 2000).

The aim here is to test the hypothesis that these institutional, economic and cultural changes might have brought about a shift in parental models that largely determine whether young women could secure their "passport" to the world of engineering. To focus solely on the period from the eighteenth century to the first half of the twentieth century, both in science (in Great

Britain, France and the U.S.: MacLeod and Moseley 1979, Abir-Am and Outram 1987 *passim*) and in technology (again in Great Britain and the U.S. but also in Germany: Canel, Oldenziel and Zachmann, *passim*, Fuchs 1997), the paternal intellectual and professional model markedly influenced the career choice of young women in these areas. For one thing, in spheres where there were still few professionals, family firms were the rule and daughters – especially if they were the only child – had to ensure the family business continued. For another thing, mothers had little if any academic scientific education and therefore the professional maternal model was far less commonplace. This was so much the case that women with a background in science – many of whom remained unmarried – formed "protégée chains" to make up for the lack of biologically-related women successors (Rossiter 1982). So, it was typically after 1945, when these mechanisms had undergone marked change and the level of feminization of French engineering began slowly to rise, that the maternal model asserted itself to a greater extent (Chantereau 1997: 161). Studying this question of parental models through the large population of students at UTBM may be especially worthwhile because it is France's fourth largest engineering college in terms of student numbers while – although part of the new generation of colleges to which entrance has been more democratic and more open to women since they were first founded – its low percentage of female students likens it to the male-dominated cultural core of military-oriented state-run *grandes écoles.*[1]

In echoes of the historical models evoked, this contribution expounds the sociological interpretive schemes of feminization and over-selection of women in nowadays French engineering colleges. It then outlines the teaching model at UTBM as a part of the explanation of (under)feminization of this college. Lastly it examines how more women have enrolled at UTBM since the founding in 1985 of the *Université de Technologie de Compiègne à Sevenan*s (Technological University of Compiègne at Sevenans, UTCS, the forerunner of UTBM) to the present day. It looks to identify the main explanatory mechanisms for the paternal model

(*epiklerate*), maternal transmission, or non-differentiation of models (modernity), while modulating the relevance of these mechanisms depending on the geographical origin of its students, partly linked to the evolutions of the socio-economic and political systems of the different countries.

Women engineers : a French-style oxymoron?

In France, "Women engineers" are still something of an exception. For the sociologist Marry, "the[se] two terms have long been antinomic and remain so in part" (Marry 2004: 3), just like it was the case for women scientist in 19th-century U.S. (Rossiter 1982: XX). French debates concerning the relations between gender and careers in science and technology currently focus on the causes of the following paradox: despite being academically more successful, fewer women than men are to be found in the more competitive scientific disciplines. Self-selection by women, proven at the time career choices are made, is not the only explanatory factor: schools and teachers play their part (Fontanini 2015: 121), as do changes in family patterns of upbringing. This is the avenue followed by Marry (2004) and Fontaine (2014). For Marry, more than "the passive interiorization of gendered stereotypes" by women, or the sexist role of schooling, the paradox can be explained by placing "the emphasis on the historical transformation of models of upbringing such as the narrowing of the gap in parental investment in the academic and vocational success of sons and daughters or maternal transmission of aspiration to greater equality between the sexes, which supposedly led to women's more active investment in academic success" (Marry 2004: 61). In following Marry, a distinction shall be drawn between "lettered *epiklerate*" and maternal transmission. By "lettered *epiklerate*", Marry sets about applying to the world of knowledge the ancient model of the *epikleros*, that is, the girl who inherits from the father for want of any male heir (Marry 2004: 117, for historical examples, see introduction). Transmission of learned knowledge from fathers to daughters,

attested to since Hypatia, is expressed in more sociological terms by Fontaine and Fontanini. It is the hypothesis of the missing or failing son that implies that the daughter becomes an engineer in the place of the son one has not had or who has been unwilling or unable to pursue engineering studies. The hypothesis of maternal transmission implies on the contrary that it is more the maternal model that plays a fundamental role in academic choices and young women's career choices. These two assumptions may be tested by a comparative analysis of the occupations of fathers and mothers, for female and male students respectively, provided a large amount of data is available.[2] Such analyses also make it possible to reply to more classical questions relating to the social origins of engineering students: a world of Bourdieusian heirs or the place of promotion of new capacities and therefore a place of modernity? To what extent does the social over-selection of women, perceived through comparison of the occupations of fathers and mothers respectively for daughters and sons, express itself? For Fontanini (2015: 122) French works of the 2000s "have made it possible to show that women's choice of these career paths can be explained by the combination of various factors such as academic and social over-selection compared with men". If, on the contrary, the parents' occupational profile is similar for both, this should be ascribed to the modernity of representations or/and to the absence, including in "engineering families", of any calling and a fuzzy career plan, with that absence and fuzziness being observable on a more global scale (Marry 2004: 128 ff.).

Technological Universities: heirs to original pedagogical models in the French landscape of engineering colleges

As an extension of the thinking of the wartime *Conseil National de la Résistance* (National Council of the Resistance) about the necessary democratization of French elites in general and science and technology professions in particular, the *Ecoles Nationales d'Ingénieurs* (National Schools of Engineers, ENI) were founded in the early 1960s, in a context of marked industrial

expansion. Then, further to the student protest movement of May 1968, the *Universités de Technologie* (Technological Universities) also contributed to the great post-war wave of creation of mixed and provincial engineering colleges.[3] Today's UTBM, arising from the merger in 1999 of the ENIBe – ENI of Belfort, founded in 1962 – and the UTCS, is therefore the heir to pedagogical models that may go some way to explaining its low degree of feminization.

The ENI model is novel: training production supervisory engineers initially in four years – instead of the five years at other engineering colleges – these establishments in some sense took over the ENAM's (*École Nationale des Arts et Métiers*, National School of Arts and Trades) traditional role of supplying mechanical engineering specialists from intermediate social strata. In the case under study, the leading local employers were Alstom (which provides French industry with major components of electricity generating stations, locomotives and high-speed train) and secondarily PSA (Peugeot Société Anonyme), both historically based in the Belfort-Montbéliard employment basin. Ever since the nineteenth century, the ENAM has undergone a process of gentrification and of higher-level and longer courses leading in the 1970s to its inclusion in the select circle of *grandes écoles* (Day 1987). The ENIBe may be thought of as an heir to the initial calling of the ENAM since, being loyal to its mission of turning out "hands-on" engineers, it was the last of the ENIs to accept to change to a five-year course in the late 1980s. The recruitment pool for the ENIBe was therefore very much male, particularly because the very large majority of students were graduates from technical high-schools.[4] The examination of admission records for ENIBe students confirms this assumption: there were just 0.4% of women in the first two decades of the college's existence, which was 10 times below the national average. The first woman engineer from ENIBe was in the class of 1971: Sylvie, born in 1951, from the *département* of Saône-et-Loire, was the daughter of an engineer father and a housewife mother, which tends to confirm the *epikleros* profile of women engineers in

what were still the pioneering days.[5] This very low rate of feminization, which relates to the very masculine culture of the ENIs in the 1960s–1970s,[6] explains in part the still below-national-average rate of the UTBM's current "Engineering and Industrial Systems Management (EISM)" branch.

As concerns the UTs, like their "forerunners", the *Instituts Nationaux des Sciences Appliquées*, (National Institutes of Applied Sciences, INSA), these establishments recruit high-school graduates preferentially on the model of the "in-house preparatory school": admission is based on academic record after an interview. This model is less selective than that of the *grandes écoles* that recruit after two years in higher education after a tough competitive examination prepared for over two years in preparatory classes that are themselves highly selective…and masculine (Canel 2000). It is therefore liable to attract more women who self-select. Nationally this type of recruitment represented some 27% of the intake in the 2010s for both genders, compared to 29–31% for women, which would put these establishments slightly above the national level of feminization (27%). We shall therefore try to explain why the "common core" at the UTBM (first two years for high-school graduate entrants) is very little feminized (15%), whereas the other route to joining the establishment, after two years in higher education, at the "branch" level, further to examination of the applicants' academic records, has a slightly higher rate of feminization.

UTBM recruitment sociology(ies): *epiklerate*, maternal transmission, and modernity

Admissions records

The admissions file for the establishment's engineering students, saved in computer format since the creation of the UTCS in 1985, is the single source for this study.[7] Although the quantitative analysis produced is rather arid, it does have the merit of containing a large number of individual data (14,243) from which to make firmly grounded sociological interpretations.

The file provides information about students' civil status, address, and their parents' address, and occupations (22 categories), whether students receive maintenance grants, and their academic profile before and after admission to the UTBM.

The primary value of this source is that it contains recent data for a very large population. It therefore means that sounder conclusions can be reached than for analyses based on a small number of observations, such as Fontaine's survey that relies on 204 responses.

Before analyzing the feminization of the UTBM student population, a geographical comment is called for. Given the different national cultural and political backgrounds, the connection between parents' socioeconomic status and rate of feminization displays marked variations depending on the student's geographical origin and warrants analysis of the sample of students residing in France separately from the other samples. The opening of the UTBM to international applicants implies a large percentage of foreign students (table 1). On a large scale, marked disparities in feminization are observed by country of residence of the parents, to take just the three best represented countries, France, Morocco, and China, with their highly varied cultural contexts.[8]

Table 1: Rate of feminization by country of residence of parents of UTBM students (1985–2016)

Country of residence	France	Marocco	China	others
Feminization rate	12.9	21.1	35.0	20.8
N of students	13,067	522	406	248
Share of UTBM population	92.1	3.7	2.9	1.3

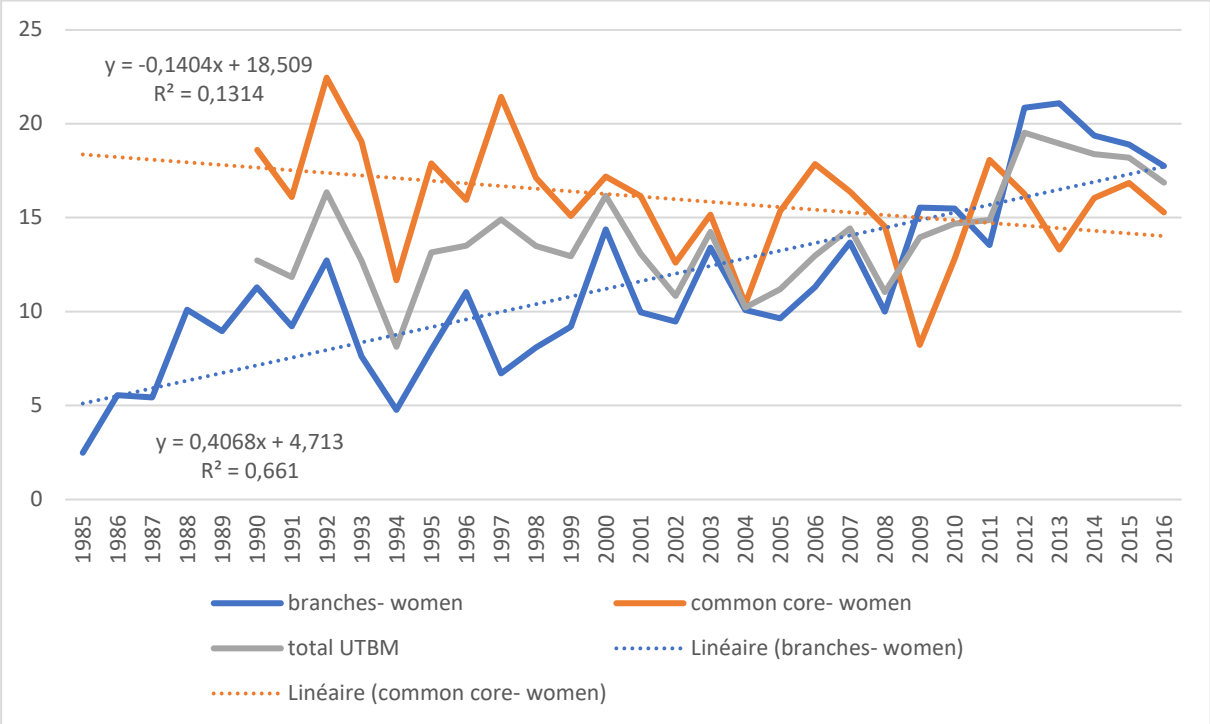
Source: UTBM, student admission datafiles.

The lowest rate of feminization is observed for France, followed by Morocco, and then China. This last rate is markedly higher than the French national average for 2016. And yet the presence of women in the French student population at the UTBM is encouraged by a higher proportion of grant students (19.5%) than for men (15.2%), while female students on average have parents of higher socioeconomic status (SES) than male students (table 3).[9] In any event, these national samples are treated separately for the analysis of parents' SES. By contrast, it is considered that the total population for the diachronic analysis is far less impacted by this surge of foreign students.

Slow and irregular feminization of the student population (1985–2016)

Analysis of the data shows very slow feminization since 1985 punctuated by periods of de-feminization, especially between 1990 and 2008 (graph 1). Then the rate of feminization surged from 2009 to 2016 (from 13.9 to 16.9%).

Graph 1: Overall rate of feminization at UTBM (1985–2016)



Source: UTBM, student admission datafiles.

Furthermore, a slight linear trend towards de-feminization for the common core is observed from 1990 to 2016 (from 18.6 to 15.3%). Given the very widespread mechanism of self-selection/elimination of women, it may be hypothesized that they are reluctant to apply on leaving secondary school but, having proved their mettle in higher education, especially after completing short courses, they decide more often than their male counterparts to continue in education to earn an engineering degree. The career paths of students studied by Fontanini confirm this hypothesis (Fontanini 2015:126), as does a verbal survey of female students at UTBM.[10] This phenomenon would also explain the seeming paradox of a lower rate of feminization for the common core than for the branches.

For the branches, feminization is steady if considered overall, from 2.5% in 1985 to 17% in 2016. There is a strong linear trend to feminization for these courses. Five branches are proposed to students entering after two years in higher education (table 2): Energy and Environment (EE), Mechanical Engineering and Design (MED), Computer Science (CS), EISM – the only branch from the ENIBe –, and finally Ergonomics, Design and Mechanical Engineering (EDME). Sociological surveys have shown that "computer science captured one sex" (males) between 1980 and 2000, whereas the French computer science was previously more feminized, as it was also the case in the U.S.[11]. This is the "geek" phenomenon, bolstered by family background and teenage and gendered use of computers.[12] In a more traditional area, the very virile reputation of the mechanical engineering options together with the sociability of workshops means these branches hold little attraction for women.

Thus, at UTBM a marked contrast can be observed between the low rates of feminization for the MED, EE and CS branches on the one side and "high" rates for the EDME and EISM branches on the other side. While the CS branch is close to the national average for this

specialty,[13] the rates of feminization for EE (9.7 %), EISM (16.8%), and MED (8.7 %), reputedly male options and typical of local industry, fall well below that average.[14].

Table 2: Rate of feminization by branches at UTBM 1985–2016

Course title	EE	EDME	MED	EISM	CS
Feminization rate	10.6	20.2	10.2	15.7	11.3

Source: UTBM, student admission datafiles.

Furthermore, after a surge between 1985 and 1993, feminization in MED falls of markedly from 1993 (16.4%) to 2016 (9.4%). Likewise, from 1989 (17.5%) to 2008 (10.8%) CS "captured one sex", males, at UTBM. Similarly, in the EE branch, the rate of feminization stagnates until 2011 (9.2%) before increasing. Even for what are reputed to be "feminized" elective programs, any teleological explanation should be set aside. De-feminization occurs in EDME after a peak in 2013 (31%). Nevertheless, this branch confirms the general idea that at UTBM like elsewhere, the more recent the specialization, the less masculine culture established, the higher the feminization (Canel, Oldenziel and Zachmann 2000).

Over-selection, epiklerate *and maternal transmission among French women students*

The occupational composition of the French subsample at UTBM is consistent with the general trend in France of a "social hierarchy of colleges that is very much related to the academic hierarchy": the proportion of fathers in "higher" occupations increases with their prestige, from 40% for colleges like UTBM that recruit high-school graduates directly to 80% for the leading *grandes écoles*, and with medium values (46–50%) for colleges with preparatory classes.[15] These "higher" occupations[16] are similar to those Fontaine uses for defining high SES parents of engineering students. As might be expected, the parents of engineering students at UTBM

dot not enjoy as high a SES as those at ENAM: on average, 30 points less (table 3), with the result that the maximum for UTBM (percentage of women students with a high SES father) is well below the minimum at ENAM (percentage of male students with a high SES mother).

Table 3: Proportion of high SES parents of engineering students at UTBM (1985–2016) and ENAM (2011–2012)

Students	Father UTBM	Father ENAM	Mother UTBM	Mother ENAM
Female	44.8	73.0	25.0	57.7
Male	39.9	73.8	22.6	49.0

Sources: UTBM, student admission databases and Fontaine, 2014.

The social over-selection of women students at UTBM only partly confirms Marry's "Newtonian law" that "social over-selection of women seems to be inversely proportional to the prestige of the colleges: very low at *École Normale Supérieure* (Normal Higher School) and the *École Polytechnique* (Polytechnic School), moderate in the other *grandes écoles*, and patent in the colleges that recruit high-school graduates (INSA and university colleges). These differences probably relate to differences in gendered educational expectations and practices of the social circles supplying these colleges" (Marry, 2004: 140). For Marry, then, this social over-selection of women students is measured and it is apparent because more female students than male students have mothers in the "higher" categories (Marry 2004: 144). This characteristic should therefore be particularly marked at UTBM, given its teaching model and the occupational profile of the parents that ranks this establishment sociologically at the bottom of the national hierarchy of engineering schools.

The figures for UTBM tend to invalidate this idea and by the same token Fontaine's hypothesis. For Fontaine, the main difference between female and male students concerning their parents'

socio-occupational profile lies not in the father's occupation (Marry's *epiklerate*) but in the mother's occupation (Marry's maternal transmission). Compared with male students, women students at ENAM have clearly more high SES mothers than high SES fathers, even if besides fathers are invariably far higher SES than mothers. The difference rises to more than 8 points between female and male students for mothers as against less than 1 point for fathers.

But for UTBM, the deviation in parents' SES is less than 5 points between female and male students, whether for fathers (4.9) or mothers (2.4). So by this criterion Marry's "Newtonian law" does not hold. There does not seem to be any premium for a high SES mother at UTBM for steering female students into engineering studies, and the difference in female/male student SES with respect to fathers seems to point to still fairly marked conformism in transmission.

Another sizeable nuance at UTBM compared with the studies by Marry and Fontaine is that Fontaine shows that at ENAM, there are far more homemaker mothers for female students (21%) than for male students (14%), which she claims is a factor in academic success.[17] But at UTBM these percentages are much the same (respectively 15.4 and 14.8%). This is an original characteristic in the more general picture that Marry paints. Marry claims that mothers of female students are more likely to be working mothers everywhere, including in Catholic schools of the *département* of Nord, than the mothers of male students. This supports the hypothesis of the impact of the "working mothers' model" on their daughters' choices.

Table 4: Occupations of UTBM students' parents, for parents living in France

Male students		
Father's occupation	N	%
Engineers and technical managers	1,597	14.0
Skilled workers	946	8.3

Teachers, scientific occupations	837	7.4
Administrative executives and corporate sales staff	822	7.2
Technicians	807	7.1
Public sector executives	567	5.0
Liberal professions	496	4.4
Workshop supervisors	462	4.1
No occupation	255	2.2
Owners of businesses ≥ 10 employees	212	1.9
Unskilled workers	197	1.7
Other	4,184	36.7
Total	11,382	100

Female students		
Father's occupation	N	%
Engineers and technical managers	320	19.0
Teachers, scientific occupations	136	8.1
Skilled workers	131	7.8
Technicians	128	7.6
Administrative executives and corporate sales staff	114	6.8
Public sector executives	92	5.5
Liberal professions	61	3.6
Workshop supervisors	49	2.9
No occupation	37	2.2
Owners of businesses ≥ 10 employees	30	1.8

Unskilled workers	19	1.1
Other	568	33.6
Total	1,685	100

Female students		
Mother's occupation	N	%
No occupation	260	15.4
Teachers, scientific occupations	190	11.3
Public sector executives	68	4.0
Engineers and technical managers	60	3.6
Administrative executives and corporate sales staff	51	3.0
Liberal professions	50	3.0
Technicians	50	3.0
Skilled workers	29	1.7
Workshop supervisors	21	1.2
Unskilled workers	17	1.0
Owners of businesses ≥ 10 employees	2	0.1
Other	887	52.7
Total	1,685	100

Male students		
Mother's occupation	N	%
No occupation	1,686	14.8
Teachers, scientific occupations	1,245	10.9

Public sector executives	391	3.4
Liberal professions	373	3.3
Administrative executives and corporate sales staff	324	2.8
Skilled workers	257	2.3
Technicians	251	2.2
Engineers and technical managers	224	2.0
Unskilled workers	192	1.7
Workshop supervisors	114	1.0
Owners of businesses ≥ 10 employees	24	0.2
Other	6,301	55.4
Total	11,382	100

Source: UTBM, student admission datafiles.

Lastly Fontaine shows that more female than male students at ENAM have parents who work in industry. This supposedly proves the importance of family background in women's higher educational choices. At ENAM, 39% of male students have a mother who works in industry, as against 54% of female students; and 69% of male students have a father who works in industry as against 79% of female students, giving female/male deviations ranging from 10 to 16 percentage points. However, at UTBM these proportions are respectively:

– Percentage of mothers working in industry, male students: 9.4%, female students: 10.6%;

– Percentage of fathers working in industry: male students 37.1%, female students: 40.2 %, corresponding to just a 1 to 3 point difference.

In short, the career choice of female students at UTBM seems to be influenced slightly more by a premium for a high SES father than a premium for a high SES mother. However, this

choice does not seem to be influenced either by a premium for the working mother or homemaker mother, nor by a premium for the educating mother,[18] nor by a premium for the mother working in an industrial concern, and more surely by a premium for the missing or failing son, because the 5-point gap between female and male students with an engineering father is the highest observed in table 4 (female/male) whether for fathers or mothers.[19] The behavior of female students might then be characterized as somewhat conservative because of the gradual drift that seems to appear from the *epiklerate* model towards the maternal transmission model.[20] However, the slight percentage differences between female and male students for key parental occupations, such as the women teacher category – Marry's "educating mother" model – like the lack of difference between females and males in terms of the premiums mentioned above, might pertain instead to the absence of calling of both male and female students whichever the engineering college,[21] and therefore a certain form of modernity (non-differentiation).

The analysis can be refined by comparing for female and male students the proportion of parents in a given occupation relative to the reference value of 100 for female students. In this way we capture the over-selection regardless of the weight of the occupation in the sample, as occupations with only low numbers may strongly influence the probability of female students enrolling for courses at UTBM. Thus, engineering mothers feature only in fifth position of declared occupations for female students (3.6%) and in ninth position for male students (2%). But in relative terms, mothers who are engineers are overrepresented by 44% in the population of female students compared with male students.[22]

So, when considering the occupations that most predispose female students compared with male students to engineering courses, it can be observed that the highest percentages are not associated with the father's occupation (engineers: +26.3%), but with the mother's occupation (engineers: + 44.4%, but also technicians). So, we find here the maternal transmission model,

but also the influence of the world of the industrial concern highlighted by Fontaine. However, it seems that in the case of UTBM, it is not so much having a high SES mother in industry as having a mother working in industry, whether high or moderate SES, that explains the career choice of female students. This is another mark of modernity compared with the ENAM population: female students seem to choose their career paths more democratically, which ties back in with the more modest profile of UTBM female students. By contrast, we do not find Marry's educating mother model, since the value associated with female teachers is just 3.5%. Conversely, we identify the parents' occupations that least predispose female students to turn to these courses. For fathers as mothers, it is unskilled manual workers,[23] for which it seems gender bias is strongest and relates also to questions of social and cultural capital.

Feminization, parents' SES, and students' geographical origins (France, China, Morocco): contrasting national models

It is not easy to unravel the skein of explanatory factors to explain the differences in SES among students of different national origins because the further away one comes from to study in France, the greater the initial financial selective filter must be. Conversely, for China we can set aside the assumption that gender bias is countered more in a "communist" country than in countries where there is no separation of Church and State as in Morocco. Although recourse to female labor and the opening of higher education to women are classical features of communist societies, Fontanini and Wu (2009) show that the proportion of Chinese female students on university science and technology courses fell from 40.3% to 30.8% between the 1960s and the 2000s. The Maoist revolution imposed the field of study and was supposed to make no distinction based on gender, whereas present-day Chinese society is – comparatively – less state-directed and gender stereotypes related to the domain of technology are commonplace (Fontanini and Wu 2009). The same trend of defeminization is observable in

East Germany, but with some differences as regarding the explanatory factors (Zachmann 2000). At UTBM, the record-beating feminization of 35% of the Chinese subsample ultimately seems to be accounted for more by the *epiklere* model than the maternal transmission model. This phenomenon does indeed originate in the one-child policy, which has been too recently abandoned to influence our sample: only-child girls are over-represented in the Chinese population and Chinese students have a very different profile from French students. For female students, the leading occupation of fathers is "engineers" (26.8%), a far higher proportion than for French female students (19%), versus "only" 14.4% for Chinese male students (French male students: 14%). The father's occupation seems to guide the choice of engineering studies more for female than male students in a context where female career choice is more influenced by parents and teachers than male students' career choices are (Fontanini and Wu 2009). The female-male gap is 12 percentage points in China compared with just 5 in France.

However, here again, it is indeed the scientific profile of both parents that seems to explain the marked presence of female students in the population of Chinese students. The second highest maternal occupation for Chinese female students is "teacher" at 16.2% as against 9.1% for their male counterparts (third-place occupation of Chinese mothers for male students). Yet, the importance of the "educating mother" is known to be important in the maternal transmission model (Marry 2004). Lastly, despite the weight of the Chinese *epiklerate*, it can be noted that the female model should not be neglected: 5.6% of Chinese female students have engineering mothers compared with 4.9% of male Chinese students at UTBM. The difference seems small but becomes meaningful when these percentages are compared with percentages for French students.

For Moroccan female students, the values observed are part of a well identified trend of markedly greater presence of women on higher education courses in engineering in North-West Africa in the last 20 years or so. Beyond that the presence of female students in sciences has

been more marked in North Africa and the Middle East but also in Central Asia than in Western Europe and North America.[24] As a result, Moroccan engineering colleges, while less feminized than French colleges through to the 1990s, are now clearly more feminized. This phenomenon is apparent in the UTBM data.[25] This is in contradiction with the culturalist stereotypes that are still widespread in the West about the place of women in Muslim societies. The occupational profiles of parents of Moroccan students suggest a number of explanations. There is a cultural and social selective filter against going abroad and pursuing engineering studies.[26] Mothers with occupations that predispose to less gender bias about women's careers are over-represented among Moroccan female students. Mothers of Moroccan female students are for 23.6% teachers,[27] which appears to be more important than the father's profession for explaining the marked presence of female students. Moreover, the leading occupation for fathers – for both female and male students – for Moroccans is teacher, whereas it is engineer for French students. The proportion of teacher parents for Moroccans is two to three times that of French parents. Therefore, on the large scale, while the *epiklerate* model seems decisive for the Chinese subpopulation, conversely it is maternal transmission that seems to come into play more for Moroccan female students. This is in keeping with Marry's pattern of social over-selection of female students (Marry 2004: 144).

One final observation is of a geographical order: on the small scale, it can be seen that, as in the medieval saying "city air makes you free", 80.9% of Moroccan female students are from cities of more than 200,000 inhabitants, versus 69.7% of Moroccan male students. Parents living in big cities have socio-occupational profiles and culturally open attitudes that tend to work against the gender bias of professional career choice.[28]

Conclusion

Examination of the UTBM student population shows that feminization of French engineering colleges does not follow a teleological narrative, especially on observing the de-feminization of the common core and the lasting marked disparities among branches. However, certain feature of modernity do appear. First, the far more modest social background of UTBM students compared with ENAM students comes as no surprise. The social promotion ensured by ENAM in the nineteenth century seems to be ensured more by universities of technology in this day and age. This is one of the features of "modern" recruitment, where the over-selection of female students does not really confirm Marry's "Newtonian law" that the more prestigious the establishment, the less intense the over-selection of female students -this over-selection occurs preferentially by maternal transmission. On the contrary, in the case of the UTBM, the gap between female and male students related to the proportions of high SES fathers seems to indicate instead a slight propensity for the *epiklerete* model as confirmed by an analysis of parental occupations. The *epiklerete* (engineer) model comes out on top for French and Chinese women students – the missing son because of the one-child policy in China – but not for Moroccan female students – maternal transmission and the "educating mother" model. Moreover, the UTBM sample invalidates some of Fontaine and Marry's hypotheses about French female students: the working mother (Marry) or homemaker mother (Fontaine) premium, and the educating mother premium (Marry). When it comes to girls, the example of the UTBM shows *in fine* the permanence of a still very masculine "cultural passport", despite important institutional and social changes, but also a relative democratization of the "social passport". Even so, an approach that erases the structure effects arising from the numbers of each occupation can be used to identify factors that may strongly influence the career choices of female students. However, because of the low numbers involved, such factors have little overall impact. Accordingly having a mother who works in an industrial setting and in a supervisory or middle management position predisposes female students to enroll on engineering courses: acculturation seems, therefore, in

part to involve a gendered model. However, although we challenge some of Fontaine and Marry's theories on the basis of a large sample, our analysis remains reductive in the face of complex family realities that are difficult to grasp, as Rossiter said of the relationship between science and gender, "so complex that they defy reduction to easy theories" (Rossiter 1987: XII).

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[1] UTBM sustains the low feminization rate of French engineering colleges with some 17% of female recruits in 2016, some 10 percentage points below the national average. Only colleges run by the Ministry of Defense have a lower percentage than the *Universités de Technologie* (Technological Universities, UTs).

[2] Our quantitative analysis, dependent on our source, is necessarily simplifying, because the male and female models are in fact much more diversified than the simple binomial father-mother: brothers and sisters, father-in-law and mother-in-law, cousins, surrogate father or mother, etc. See the references of our introduction.

[3] The first at Compiègne in 1973.

[4] In the year 2000, feminization of ENI stood at 6.8%, versus 23.1% on the national scale.

[5] Jeannette, born in Strasbourg in 1953, the second woman to be admitted in 1973, confirms this trend: an industrialist father and a homemaker mother.

[6] on the very masculine culture of mechanical field, see among many others Oldenziel 1999 and Day 1987.

[7] I am grateful to Nicolas Créantor of the computer department for his help with this project.

[8] A secular country and with a mainly Christian religious background, a non-secular Muslim country, and a "communist" country.

[9] Nevertheless, over the period, there is no official policy of UTBM to encourage female entries, or even female applications (interviews with the successive educational directors).

[10] Current or former female students applying for the common core all steered clear of what are considered the most prestigious/demanding programs, and those joining at branch level come rather from short or non-selective programs. All speak of lack of self-confidence. Survey conducted by Laura Perrin and the present author in February–March 2021.

[11] See the contribution of Pierre Mounier-Kuhn in this book.

[12] Collet 2006. For a general analysis, Ensmenger 2010 and Abbate 2012.

[13] 2009–10 figures: 17.8% (UTBM), 15.8% (national).

[14] Ditto 2009-10: EE (national): 16.5 %; EISM: 22.4%, MED: 19.5%.

[15] Marry 2004: 135 ff. These figures are for the 1980s but the author points out the "stickiness" of social and academic structures over the long term: the proportion of fathers of engineering students in the "higher" professions was 50% in the 1960s as in the 1980s, even if the proportion of engineers and executives in the working population rose markedly in the meantime. Comparison of our data with the Marry's earlier data or Fontaine's mostly

later data (2011–12) therefore involves little structural deformation arising from changes in the working population. Just for the years 2011–12, the UTBM values in table 3 are very similar to values for the period 1985–2016: 46.2% of female students with a high SES father and 26.7% with a high SES mother; 43.2% of male students with a high SES father and 24.6% with a high SES mother.

[16] Owners of businesses with 10 or more employees, engineers and public- or private-sector executives, liberal professions, high-school teachers, researchers.

[17] In an unpublished survey of 91 students at UTBM in 2015, female students (8.1%) are much more wary of being geographically remote from their parents than male students (1.9%) are.

[18] Table 4: almost identical percentages of mothers who are teachers for both male and female students.

[19] The datafile does not give details about siblings. However, the survey of 91 students shows that at the end of the period (2015) 16.2% of female students were only children versus just 5.7% for male students.

[20] If only mechanically because of the greater numbers entering higher education. This means the mothers generation have access to positions of responsibility: cf. Fuchs 1997 *versus* Mellakh 2004.

[21] Marry 2004:128 ff. For Marry, it is a matter only of lack of vocation for the occupation, not an absence of a scientific vocation or a taste for academic ranking. This trend is confirmed by our interview survey of 2021.

[22] [(3.6-2)/3.6]*100 = 44%.

[23] And also business owners for mothers.

[24] Feminization of engineering colleges has risen from about 20% in Morocco (1996) and Tunisia (2000) to more than 42% in 2018.

[25] No Moroccan female students at UTBM before 1998, then a greater surge between 2000 and 2010 (+7.1%) than for French female students (+3.6%) and even for Chinese female students (+6.1%). This confirms the boom in feminization in Morocco as from the 1990s, which is consistent with the mass entry into higher education, but also the diversification of courses after the era of the prevailing state model (Mellakh 2004: 317 ff.).

[26] Modest occupations are not as common as in the population studied by Mellakh. Conversely the proportion of non-working mothers is just 27.3% for female students versus 87.4% in Mellakh (Mellakh 2004: 320–21).

[27] 11.3% for French female students.

[28] This is not the case of either French or Chinese female students for whom the percentages are very much alike compared to percentages for their male counterparts.