

Giving a *Conférence* at the *École polytechnique* at the end of the nineteenth century

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Abstract

*During the nineteenth century, training at *École polytechnique* was divided between courses in the lecture hall and studying in smaller rooms. At the end of the century, the school decided to set up some additional *Conférences* as it existed in other institutions. The purpose of this paper is to explain what the goals of the teachers who gave these *Conférences* were. To this end, we shall focus on debates in the Teaching Committee of the school and on the content of the *Conférences* according to reports in the archives of the *École polytechnique*.*

Keywords: history of teaching, France, *École polytechnique*, nineteenth century.

Introduction

The *École polytechnique* is a famous engineering school created just after the French Revolution in 1794. During the nineteenth century, many great mathematicians (Joseph-Louis Lagrange, André-Marie Ampère, Augustin Louis Cauchy, Charles Hermite, Henri Poincaré, etc.) taught in this school. We will see that, until the 1870's, the form of teaching was quite the same every year, divided between lectures and oral exams. Nevertheless, in the 1870's, a new form of teaching appeared: some *Conférences*. This paper aims at explaining the context of this change, analysing debates in the Teaching Committee of the school and describing the content of the *Conférences*.

In the historiography, a lot of studies deal with lectures given at the *École polytechnique* (Belhoste, 2003; Picon, Belhoste, & Dahan Dalmedico, 1994; Renaud, 2017, pp. 115-180; Ehrhadt, 2009; Gilain, 1989; Dupont, 2000; Gentil, 2002). Concerning the 1870's, Gispert (1994) gives a lot of information about the analysis course too. Thus, one can consider that lectures given at the *École polytechnique* are well known by historians. On the contrary, and to our knowledge, nobody earlier explored the topic of the *Conférences*¹.

This paper mostly uses some sources taken from the archives of the *École polytechnique*. On the one hand, the reports of the Committees of the school are available in the archives. There were actually two different Committees: the *Conseil de perfectionnement* and the *Conseil d'instruction*. The first one gathered some members of the administration, some representatives of the Ministry and a few teachers. It was a kind of Administrative Committee for the school. The second one was smaller and only teachers could become members. Most of the time, it attended to pedagogical issues. For this reason, one can consider the *Conseil d'instruction* as a Teaching Committee. All the reports of both *Conseil de perfectionnement* and *Conseil d'instruction* give extensive information about the organisation of the *Conférences* and their evolutions until the end of the nineteenth century. On the other hand, the archives of the school also contain reports of some *Conférences* given between 1884 and 1895. Generally, these reports are classified at the end of the course written by the *Professeur* himself or by some students. Due to these reports, the content of *Conférences* can also be studied.

That work with the archives will allow for describing what exactly a *Conférence* at the *École polytechnique* looked like. What was the goal of the administration and the goal of teachers when they started to give *Conférences*? What were the debates about in the Committees of the school? What did a *Conférence* look like in practice? How free was a teacher when choosing the subject of a *Conférence* and then dealing with it?

To answer such questions, this paper falls into a few parts. The first part will deal with the situation of mathematics teaching at the *École polytechnique* before the 1870's. The second part will present the situation in other French schools where some *Conférences* were also in use at that time. It will allow us to understand the context in which the *École polytechnique* decided to establish *Conférences*. Then, the following parts will narrow down the focus on the *Conférences* in the *École polytechnique* itself. In the third and fourth parts, we will outline the beginning of *Conférences* at the *École polytechnique* and their first five years. These parts explain what the decisions taken by the Committees were, what they discussed and how the system of *Conférences* settled down after this first period. The fifth part will detail a few examples of *Conférences* due to the reports of the archives and the last part will then focus on some evolutions in the 1890's.

There is only one sentence about *Conférences* in (*École polytechnique*, 1895, p. 84).

Situation before the 1870's at the Ecole polytechnique

As written in the introduction, mathematics teaching at the École polytechnique consisted basically in giving some courses and in controlling students progress thanks to oral tests. These tasks were not carried out by the same people and there were two different Statuses for teachers: the *Professeurs* and the *Répétiteurs* whose function was similar to that of assistant professors (Belhoste, 2003, pp. 183-190). On one side, *Professeurs* gave ninety-minute lectures in the lecture hall where all the students in the same year group listened to them. For instance, the lectures of analysis were given three times a week and the ones of mechanics twice a week. If we consider all the subjects, there were between ten and fifteen lectures a week. At the end of the semester, *Professeurs* were also supposed to give a few exercise sessions to train students. On the other side, *Répétiteurs* were in charge of assessing and marking students. In spite of the irregular frequency of oral exams, one can consider that every student was assessed around once or twice a month for each subject (Vincent, 2019, p. 131). In addition to oral exams, *Répétiteurs* could also help students to revise their lessons in small rooms during specific sessions. It should be noted that the time spent by students to revise their lessons and to do exercises was even longer than the lectures themselves. They usually studied more than thirty hours a week in small rooms.

Actually, the Committees of the school often discussed how to organize teaching. In addition, the system of oral exams evolved several times. Obviously, this paper cannot give all the details about every reform. Nonetheless, the reform of 1850 has to be mentioned as regards the subject of this paper. Indeed, in 1850, it was decided, among other things, to transform the organization of oral tests. *Répétiteurs* assessed simultaneously six or seven students in a same session of two hours. They were supposed to grade the students and to give some additional explanations at the end of the session. Thus, the Teaching Committee expected students to have longer conversations with the teachers and learn from these discussions. Because it gave opportunity to *Répétiteurs* not only to evaluate students' skills but also to get more involved in the teaching, this reform of 1850 could be considered as a first step towards *Conférences*. However, these sessions with six or seven students remained closer to oral exams than real *Conférences* and their main purpose was still to evaluate and to grade students. This reform was even discarded after a few years because it was too difficult for *Répétiteurs* to have

a clear idea of each student's skills and to give individual grades in these conditions (Belhoste, 2003, p. 190).

Finally, and despite a few reforms, the division of teaching at the *École polytechnique* between *Professeurs* and *Répétiteurs* was operative throughout the nineteenth century and their roles remained largely unchanged before the 1870's.

Situation before the 1870's in other institutions

The *École polytechnique* did not invent a pedagogical system with *Conférences* in France. Before the 1870's, other French institutions set up such a system (Noguès, 2008). For instance, from 1810, at the *École normale supérieure*, some *Conférences* were scheduled: “students talk about issues they had during the past lessons, they compare different methods and they do experimentations in physics or in chemistry again (Marais de Beauchamp, 1915, vol. 1, p. 273)”. The number of students at the *École normale* was very limited, fewer than twenty students for each year. Therefore, *Conférences* were set up with very small groups in order to organize the work of students.

In some ways, this system of *Conférences* was an example for other institutions like the *École pratique des hautes études*, created in 1868. In this school, students took a course at University and some *Conférences* in their school in which they could practice the subject of the course (Marais de Beauchamp, 1915, vol.2, p. 273). In both *École normale supérieure* and *Ecole pratique des hautes études*, *Conférences* had to do with practice and exercises of applications.

Finally, *Conférences* also appeared in Universities in 1878 after a major reform. Some French Universities could sometimes deplore that lectures attracted a lot of unregistered students but not so many regular students. The latter actually preferred some other schools where they could have more support in their training. Then, *Conférences* were created by Universities as a tool to change their audience and to offer more regular lessons. A new status was created, the status of *Maître de conférences*. Naturally, they were in charge of these new *Conférences* (Marais de Beauchamp, 1915, vol.3, p. 167). They had to organize some sessions where the main purpose was to train students with exercises and to speak about the major difficulties they had. Also, the seminars organized by German Universities were often held up as a model (Liard, 1890, p. 54).

Thus, the *École polytechnique* was not the only school to set up some *Conférences*. At the same time, in other institutions, similar changes happened too. The following parts will reveal what the common points but also differences between *École polytechnique* and other institutions were.

Introduction of the *Conférences* at the *École polytechnique*

In the 1870's, Joseph Bertrand was the first one who proposed to introduce *Conférences* at the *École polytechnique*. He thought that there were too many exams at the *École polytechnique* and wanted to reduce the role of *Répétiteurs*, to make them as “*Maîtres de Conférences*” (Conseil d'instruction, 8 November 1873). This proposition failed but *Conférences* were created very shortly afterwards. In 1874, the director of studies, Ossian Bonnet, proposed to introduce *Conférences*, given by *Professeurs* and *Répétiteurs*:

M. Bonnet proposes to dedicate, every year, for the courses of analysis and mechanics, eight sessions to familiarize students with applications of the theories. It would be *Conférences* given by the *Professeur* of the course and by the *Répétiteurs*. Each year of students would be divided in four groups². [...] The president [of the Teaching Committee] reminds that, from 1853, the teachers were supposed to give some sessions of review after their course [at the end of the semester]. This proposition would consist in replacing these sessions of review by some *Conférences*. (Conseil d'instruction, 19 May 1874)

A few days later, the administration debated again about the *Conférences* (Conseil d'instruction, 27 May 1874). They decided to distinguish two types of exercises. Firstly, when teachers could easily change the figures of an exercise, students had to do it alone, in small rooms. Then it was impossible for students to copy on each other because all of them had a different calculation to do. This was the case mostly for exercises in astronomy. The second type of exercises were when teachers could not change the figures in the question. For these exercises, especially for the ones related to the applications of the courses in analysis and mechanics, eight sessions were scheduled. During half of the sessions, students had to do exercises of applications related to the course. And after each of these sessions, the teachers marked the exercises and gave a small *Conférences* in order to propose a correction of the exercises.

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Each teacher was supposed to give his *Conférences* for the same group.

Many debates in the first five years of the *Conférences*

During the first years, there were many debates in the Teaching Committees to decide how to organize the *Conférences*. In 1874, students were divided into four groups, as suggested by Ossian Bonnet and the *Conférences* took place in the lecture hall. In the following years, each of these four groups was also sub-divided into smaller groups of fewer than ten students. Teachers had to repeat their *Conférences* for all the groups. It is possible that such a decision was made to encourage discussions between teachers and students. Nevertheless, it took a lot of time for the teachers and they could not give many *Conférences*. That was a reason why the groups were getting bigger after a few years. In any case, in the debates of the Committees, the issue about the number of students of each group was often debated. In parallel, discussions about the composition of groups also dealt with the students who were to be chosen. For instance, some teachers would have liked to form some groups depending on the level of students. In their views, it could permit to give more specific *Conférences* and enable them to adapt. Nevertheless, this solution does not seem to have existed in practice.

In 1877, the Teaching Committees of the school decided to end the four exercises sessions and to replace it by *Conférences* which were supposed to present a few applications of the course. This time, the debates in the Committees concerned uniformity of the teaching, which was linked to the meritocratic ideology of the school (Belhoste, 2003, chap. 10). All the students were supposed to have the same opportunities and were judged only on their own abilities. Consequently, the multiple ways to mark students were seen as a real problem. That is one of the reasons why the exercises sessions were ended in 1877 (Halphen, 1879). Thus, after three years, the original goal of the *Conférences* which was not only to train students but also to evaluate them had changed. From 1877, *Conférences* were basically sessions to train students in the wake of lectures and to give them exercises of applications without giving any grades anymore.

In 1879, after a few years of existence of the *Conférences*, it was time for an evaluation. Georges Halphen, a *Répétiteur*, was in charge of writing a report in which he asked to give more importance to the *Conférences* (Halphen, 1879). One year later, in 1880, the members of the Teaching Committee followed his point of view (Conseil d'instruction, 10 November 1880). In particular, they decided to form bigger groups, with at least fifteen students in each group. So, teachers had more time and were able to give

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more *Conférences*. Moreover, with the same goal, the Teaching Committee reduced the number of hours dedicated to oral exams. And *Conférences* were now given in all subjects while before 1880, it had concerned only the course of analysis and mechanics.

Finally, the contradictions between the activity of teaching and the activity of evaluation are interesting to notice. In any case, the Committees had debates about these contradictions and they decided to give priority to one over the other.

A few examples of *Conférences* in the 1880's

In the 1880's the system of *Conférences* became more stable and nothing really changed in their organisation. During this decade, fewer debates of the Committees related to the topic of *Conférences*. For that reason, the reports of the Teaching Committees will not be so helpful for this part. However, as said in the introduction, the *École polytechnique's* archives contain some reports of the *Conférences*. It enables to give a more complete description of the *Conférences* during that period.

To be more precise, in the *École polytechnique's* archives, there are eighty-two reports of *Conférences*, from 1884 to 1895 (Jordan, 1884-1895; Bertrand, 1886-1895). The two tables give the number of reports there are for each year and for each teacher³. Most of the time, there are about two or three reports by teacher and by year.

Table 1. Numbers of reports of the *Conférences* relative to Jordan's course

Year	Jordan	Halphen	Flye Ste Marie	Laguerre	Poincaré	Humbert	Lévy	Total
84-85	3	4	2	1				10
85-86	3	2	3	3				11
86-87	3		1		3	2		9
87-88	3		3		2	2		10
88-89			3		3	3		9
94-95						2	2	4

³Most of the teachers who gave some *Conférences* were some *Répétiteurs* of the course.

Table 2. Numbers of reports of the *Conférences* relative to Bertrand's course

Year	Bertrand	Laurent	Liouville	Koehler	Carvallo	d'Ocagne	Total
86-87	2	3	3				8
87-88	2	3	4	3			12
89-90		4	2				6
94-95					1	1	2

Thanks to the reports, a few phenomena can be noticed. First, some results and methods are taught by most teachers. For instance, we often find Poncelet's theorem in the reports. The proof of this theorem was commonly used to illustrate the course about Integral Calculus. Lots of *Conférences* also dealt with computing of complex integrals or elliptic functions and their applications. It means that, even if there were no curricula for the matter of the *Conférences*, teachers often made similar choices and there were standards of some sort.

Furthermore, the reports show another phenomenon. When a teacher gave three *Conférences*, one was usually about differential equations and another one was about integrals and elliptic functions. The last one dealt with more varied topics. This division appears for most teachers and, according to the reports, there were standard choices for the topics of the *Conférences*. However, there were also some differences between teachers. For example, even if the *Conférences* were supposed to be applications of the course, the content was more or less theoretical, which depended a lot on the teachers. On the one hand, some reports look like a series of exercises corrected by the teacher. In that case, a *Conférence* was a kind of exercises session which required a lot of skills when it came to calculation. On the other hand, some *Conférences* were more theoretical. It was sometimes an occasion for teachers to define a mathematical concept and to present some general methods to solve a problem. They included calculations in these *Conférences* as applications of a general point of view presented just before.

Some teachers used to give *Conférences* of the first type and others gave *Conférences* of the second type. For instance, the *Conférences* of the year 1885/1886 give a typical example of this division between teachers. On the one hand, Camille Flye Sainte-Marie and Georges Halphen proposed applications which needed lots of calculations. On the other hand, Edmond Laguerre gave more theoretical *Conférences*.

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One of the *Conférences* given by Flye Ste-Marie dealt with solving differential equations with infinite series. He used a method presented in the Jordan's course and solved an equation similar to Jordan ($y^4 - y^2 x - 2yx^2 - x^3 = 0$). Another *Conférence* by Flye Sainte-Marie was about the study of the integrals. His goal was to determine conditions on some parameters to obtain an integrated function. Georges Halphen proposed a kind of exercise of application in his first *Conférence* about the evolute of a particular curve. His second *Conférence* was nevertheless more general and presented the method of substituting to solve differential equations. Halphen dealt with lots of cases and explained how to choose the substitution in practice.

Regarding Laguerre's *Conférences*, the first one was about the function series on the boundary of the disc of convergence. At the end of this *Conférence*, he presented a few results about Fourier's series, a part of the curricula of the second year at the École polytechnique. Then, this *Conférence* by Laguerre was not only an application of the course but also introduced a new subject. Laguerre's second *Conférence* was about geometry, in which he presented a theorem about the curvature of a surface and its applications and his third *Conférence* was about Integral Calculus. He

proposed to compute approximations of integrals such as $\int_t^{+\infty} e^{-ax} f(x) dx$. To this end, he developed the functions with Taylor polynomials. He explained that the rest of the Taylor series does not converge even if it is very small for some values and he could obtain a good approximation of the integrals. He called this phenomenon "demi-convergence". This example is interesting because, at that time, some other mathematicians worked on this notion of demi convergence. In particular, Poincaré wrote about this notion in *Les nouvelles méthodes de la mécanique céleste*, trying to make it more stringent (Poincaré, 1893, p. 1). Finally, we can see that Laguerre used the *Conférence* as a tool to train students with applications of the course but also to introduce a mathematical subject that students did not know yet. Throughout the decade 1880, the same kind of practice existed from time to time and by teachers even if it was not so common.

Some evolutions in the 1890's

The main goal of the *Conférences*, which was to present some applications of the course, did not change in the 1890's. However, some evolutions can be

noticed. For example, the number of students by group increased again. The groups were composed of 50 students and at the end of the century, *Conférences* were given for students belonging to the same year group (around 200 students) at the same time (Conseil d'instruction, 12 January 1897).

Moreover, the reports are a marker of other evolutions of the *Conférences* at the end of the nineteenth century. Firstly, the reports became much longer. It is usually more than ten pages, while it is only three or four pages for the reports of the 1880's. Owing to the number of *Conférences* per year and the number of pages of the reports, one can assume that a single *Conférence* ran over the course of several sessions. It was undoubtedly a big change for this decade of 1890's. Secondly, the *Conférences* were now organized in a more structured format. They were shaped in several parts: introduction of the problem, historical point of view, definitions, theorems, applications to physics, etc. Last but not least, some of the *Conférences* were not given by the *Professeur* or the *Répétiteur* of the course. The guest teacher was invited by the *Professeur* especially for the *Conférence* because of his abilities. For instance, in 1895, Maurice d'Ocagne gave a *Conférence* about nomography, one of his subjects of research, and Emmanuel Carvallo did the same about numerical equations. They were both external teachers of the analysis course. D'Ocagne was a *Répétiteur* of the astronomy course and Carvallo was an examiner of mechanic at the *École polytechnique* but he was not a *Répétiteur* or a *Professeur*. In comparison, this possibility for the *Professeur* to invite a guest does not seem to have existed before. Of course, all these evolutions have to be understood in connection with the increasing number of students we have already mentioned.

Carvallo's *Conférence* is actually a perfect example to illustrate the changes which happened in the 1890's (Vincent, 2020b). His *Conférence*, given in 1895, presented Gräffe's method and some applications. The report, written in about forty pages, is divided in five parts:

- Theory of the numerical resolution of algebraic equations;
- Practice of the method;
- Approximation method;
- Extent of the method for transcendental equations;
- Application to physics.

The report of Carvallo's *Conférence* was almost the same as an article he published in *Les annales de la faculté des sciences de Toulouse* a few years

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before. In the introduction to this article, he wrote explicitly: “It was useful to make the method more rigorous in order to teach this method” (Carvalho, 1889, p. 4). This sentence proves that Carvalho had some pedagogical motivations when he researched about Gräffe's method. In some ways, the *Conférence* gave him the possibility to teach it as he expected and to pave the way for teaching Gräffe's method. This is an interesting example of a link between teaching and research at the École polytechnique during the nineteenth century⁴. This is especially true given that Carvalho quoted scientists of his time who were working on numerical equations and their applications. He quoted several times some notes published in the *Comptes rendus hebdomadaires de l'Académie des Sciences* which can be considered as research studies: (Kirchoff, 1849; Mercadier, 1887; Mercadier, 1888). Carvalho gave the possibility for students to go further and to take a real interest in academic works.

Table 1. Principles of Gräffe's method

- If the roots of a polynomial equation are ranked by descending order, and if every root is much higher than the followers, then Vieta's formulas give an approximation of the roots.
- For a general equation, compute a new equation whose roots are in the first configuration.

This link between teaching and research is certainly a common point with a few *Conférences* of the 1880's. Nevertheless, the link became stronger and more common in the 1890's. Thus, the standards did change.

Conclusion

At the beginning, *Conférences* at the École polytechnique were linked to the exercises sessions and were given in front of small groups. In that way, they were similar to *Conférences* given in other institutions in the nineteenth century (Noguès & Boris, 2008). The link with exercises sessions shows that it was also a way to combine oral and written activities in a school where the teaching mostly relied on oral activities (Waquet, 2003; Belhoste, 2002). Nevertheless, there existed a few specificities of the École polytechnique.

⁴Actually, the topics of numerical equations give several examples of link between Teaching and Research at the École polytechnique during the 19th century (Vincent, 2020a).

Conférences were first linked to evaluation, which was not the case in other French schools. Contrary to the Ecole normale supérieure, the number of students in the entire institution was high. Many issues arose from it and the size of groups kept evolving until the end of the nineteenth century. Contrary to Universities, the introduction of *Conférences* at the École polytechnique did not create a new status for teachers. *Professeurs* and *Répétiteurs*, whose status already existed in the school, were in charge of the *Conférences*.

Finally, after less than two decades of existence the substance and the form of *Conférences* both evolved. Increasingly, *Conférences* could also be a way for teachers to present their own research or a subject linked to their own research. It is maybe one of the most significant evolution of the *Conférences* at the end of the nineteenth century. This point is especially relevant because the issues about links between teaching and research were often pointed out by historians and used to describe the dynamics of the teaching at the École polytechnique (Belhoste, 2003, chap. 8). Considering the history of *Conférences* can actually bring a new perspective to the debate.

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