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Two teaching approaches in geotechnical engineering

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Teaching to future engineers raises many questionsthatmay be divided into three categories. The first one seems to be often forgotten compared to the theoretical knowledge: "what should an engineer know or rather what he should know to do?"Naturally follows the second category of questions, after "what to teach?", is "how to teach?". The third one appears automatically "how do our students learn?" We will see that the way the students learn depends more on the choice of the assessment process. Obviously all these questions are connected together and lead to many others questions. It will be sure that, as teachers, we have much more questions than answers or solutions.

Trying to consider all these aspects, I propose two approaches of geotechnical lessons to my studentsat ESTP ("EcoleSpéciale des Travaux Publics, du Bâtiment et de l'Industrie") depending on the notions to pass on. ESTP is one of the French "GrandesEcoles" which will be furtherpresented on this communication.

In the first category a preliminary question could be:"**what is an engineer?**" Different definitions can be found. The CTI (Commission des Titresd'Ingénieur - Engineering Degree Commission) has adopted the following global definition of engineering(CTI Web site): "*Engineering can be defined as the posing and answering of complex questions in an effective and innovative way, in the fields of creation, design, production and implementation, within a competitive environment and with a focus on products, systems or services, and possibly their financing and sale. As such, engineers should have a good understanding of technical, economic, social and human issues, based upon a solid scientific background*."And the ESTP considers that the objective of French engineering education is to provide (ESTP Web site):

- ✓ a <u>high level general scientific knowledge</u> that enables the engineer during his whole professional life to evolve and to adapt to new techniques;
- ✓ a specialized education that will allow him to possess <u>technical skills</u> and to be operational as soon as he graduates;
- ✓ a thorough general education that will prepare the future engineer to become a manager in the international market;
- ✓ an introduction to applied research and innovation activities in order to <u>train creative, innovative and open-minded professionals.</u>

We can notice (see the underlined words) that not only the knowledge but also the know-how are aimed at, and even more, their capacity of evolutionin order to adapt themselves to new concepts/tools/situations/technologies … In civil engineering, the necessary job skills should be able to solve problems, i.e. to understand, to analyze and last but not least to make a decision. Now we know the goal to reach, the question is "how?" And this "how" depends on **how our students learn**, which means that we should look at their basic education.

For that we should explain the French higher scientific curricula. In France, the title of "engineer" and the professional habilitation that goes with it, is awarded with five year degree, accredited by a national authority, theCTI. Studies are normally accomplished in a "Grande Ecoled'Ingénieur". Indeed because of many political conflicts since the 16thcentury, the French higher education is very specific, the only one of its kind in Europe with its "GrandesEcoles" (which is translated literally as"Higher Schools") as "Ecole des Ponts" since 1747, "Ecole des

Mines" since 1783, "Ecolepolytechnique" and "EcoleNormaleSupérieure" since 1794). Even if a real definition of this kind of advanced education doesn't exist, today approximately 170 public and 68 private higher schoolsare authorized to deliver the engineeringdegree(ATTALI, 1998).Thus, to follow higher scientific curricula (until master degree), Universities, "higher school" and so-called "Classes higher integrated school" are proposed. The "GrandesEcoles" are distinguished by a highly selective admission process, a limited number of students and quality programs, after generally two years in specialized institutions, so-called "Classes préparatoires aux GrandesEcoles" ("Preparatory course for entrance to GrandesEcoles"). Only the best students, with high marks in scientific subjects at the secondary education are admitted. The syllabus of these classes is focused on sciences (mathematics, physics, chemistry, general engineering science).(ESTPWeb site), and their teaching are more theoretical and rigorous in order to prepare to competitive examination, there is no space time for practical learning. According to the observatory ofstudent's life, a student in this kind of training works near 60 hours a week (ONISEP Web site). The numbers of studentsislow, and the evaluations are numerous and regular. However, it is well known that the kind or type of **assessment** influences the learning process of the student. I think that it is often their first question to their professor: "What are you expecting us to know? What kind of evaluation we will have?" The evaluation conditions the process of learning. We can quote DE KETELE's sentences (1993, in RICHARD, 2004): "Tell me how you assess and I'll tell you what your pupils or students learn really […]".Thus the educational treatment of knowledge generally appears inseparable from the processes used to assess it. Indeed several roles of assessment can be cited: (ENDRIZZI and REY, 2008)

- certification assessment, i.e. to prove of training;
- summative assessment, i.e. to check whether knowledge and competencies have been acquired;
- forecasting assessment, i.e. to assess the level reached and the student's potential to continue in one way or another.

Many studies deal with the evaluation, which has a central place in sciences of education (LIEURY and coll., 1996, in LETE Bernard, 1999). But even so, we realize that everywhere in the world the School system attaches too much importance to the assessment of the learning and not enough to the assessment FOR the learning (SMITH, 2009). Nevertheless the term assessment often makes a reference to a summative one: a makk is given for each knowledge to require at a given time.From this outcomes issue, the student has to make the efforts to work again on his paper in order to make progress and complete his learning, and in an autonomous way(VINCE and al., 2007). We have many doubts about such a process. That's why several solutions in order to help students to understand their weaknesses are developed, such asrubrics, scoring scale used to assess student performance along a task-specific set of criteria (MUELLER, 2012, DANNELLE and LEVI, 2004, DAELE and BERTHIAUME, 2011, …).

We presented previously the necessary engineer job skills, the curricula and the process of learning of the French student intended for the "GrandesEcoles". Now we can tackle **how to teach**. In France, to teach in higher education there is generally no obligation to undergo formal training. But some studies seems to show that for the higher education teachers learning to teach is still a taboo, and the idea of training and support is often seen as a sign of either de-professionalization or professionalization (ENDRIZZI, 2011). Sometimes professionals give a lecture. The share of their background is very interesting for a practical learning, but they are not better trained. As ENDRIZZI (2011) writes on the teachers coming from the research: "The

identity of the profession is also primarily a matter of allegiance to a particular discipline: academics are researchers first, teachers second". Finally, the choice of the teacher is only based on his good expertise without watching his educational abilities. The case of academics teachers in higher education can be gone deeper with the paper of REGE COLET and BERTHIAUME (2009, in ENDRIZZI, 2011).I think that it is today difficult for a researcher to dose out his involvement and his pending times for learning task. Furthermore that the researchers are currently assessed only on their research, without regarding their performance in education, leading today to the food for thought. It is commonly considered that two approaches to teaching exist:

- the "teacher-centered" or a "content-based" approach – the students are seen like a passive receivers of the knowledge (content) transmitted by the teacher;
- the "student-centered" or a "learning-based" approach – The teacher focus on facilitating learning.

Maybe a few words about geotechnical engineering learning: it should be taught in different ways. It can be done through a stable and "definitive" view or conversely by putting emphasis on the partial and scalable nature(Gambin and Magnan, 2000). Gambin and Magnan [2000] suggest using the history of geotechnical engineering to teach because it gives "*an opportunity to draw the students' attention, to show them the constant evolution and relativity of knowledge, to illustrate the role of observation and experimental analyses in the activities of engineers and help the students in understanding the particularities of geotechnical engineering with respect to mathematical and mechanical sciences […]".*

When I began teaching geotechnical engineering at ESTP I thought to teach like my higher education teachers did. Thus I thought to present at first the soil mechanics as organized for example in the well-known books of Schlosser's (1997) or Philipponnat and al. (1999).Like many young teachers (DEMOUGEOT-LEBEL and PERRET, 2010a and 2010b, in ENDRIZZI 2011), I was so anxiousthat my teaching approach was completely teacher-centered, headed more for subject knowledge than student support. Once passed the teaching stress of this first year, I could be able to think on **what was important to transmit**. According to the WIGGINS and MC TIGHE (1998), the "Enduring Understanding", "What is important to know and to do", and "What is non-essential but worth being familiar with" should be defined. Concerning the geotechnical engineering learning, I think that the most important is to understand and to analyze (critic approach) a geotechnical report, to be able to discuss with geotechnician and to deal with all the stakes and identify all the risks…I began thinking about what they understand and memorize, and above all "why?", then how they learned. And now I think that they often looked only to obtain a good assessment. It was mainly scramming, they just learned by rote, because our often certification assessment leads to this process, mainly with the Preparatory course for entrance to "GrandesEcoles". But, I think that our role is to transform our students in good professional, and then they should have sustainable knowledge and analyze skills. Then the question for me was how to make understand the utility of some knowledge in Geotechnics. Then I began to redesign**pathology centered knowledge**. The easiest subject is undoubtedly the swelling and shrinkage of clay, which permit, among others, to introduce what is the soil, its origin, its characteristics, the nature's influence on its behavior and so,many laboratory tests (Atterberg limits ,Particule-size analysis, …), but even the three kinds of water (hygroscopic, capillary, gravitational/free). What is even more interesting is to show the students the tight link with the structure's behavior. My teaching approach tries to put

emphasis on the understanding of physical phenomena, because I think that it facilitates the sustainable memorization. This entrance by the pathology or the physical phenomena lends itself to the soil mechanics, but it is less adapted to teach engineering design. I would like laying great stress on the place of the geotechnical in the building out. Thus I opted for the **project based learning approach**. The goal is to make them a kind of geotechnical report. According to the geotechnical map they should define the geological profile and determine all the possible risks (and quote which are not concerned) with all the necessary justifications. After that, they should determine the geotechnical investigations, i.e. "which tests?", "where?", "how many?"… I give them the tests results and they should choose the kind of foundation and design it. Sometimes, they should design a pumping rate and a retaining system.
I think that with the project based learning approach the students follow all the activities of Bloom taxonomy (BLOOM, 1954), i.e. "remember", "understand", "apply" and "Analyze-Evaluate-Create". And when we analyze the project by the Eight learning events model (LECLERCQ and POUMAY, 2005) we use six learning activities: "Receive information" + "Explore"+"Experiment"+"Create"+"Self-reflect" (missing learning activities: "Imitate", "Exercise", "Debate"). Concerning the project based learning approach we can refer to the Catherine Reverdy's paper (2013).
One last important thing is to give to the students a detailed **syllabus** which includes not only the course outline, but even the expectation of the professor and the outcomes of this teaching and a real place in the curriculum of future engineers.

Since my teaching experience is not very long, I can't say that the approach by the pathologies or the project based learning approach are very decisive, I should set up a feed-back assessment. Nevertheless, these approaches allow students to realize the link with real engineer's situations and difficulties. They are openedto cross-disciplinaryapproaches …
Finally I also think that some learning doesn't require teachers, i.e they don't provide a real support, and thus I would like to test the flipped-classroom in the near future.

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