Supervised Professional Practices: Research as Option to Strengthening Knowledge in Geotechnical Practice

S. Orlandi[1], D. Manzanal[1, 2]

[1]*Universidad Nacional de la Patagonia (UNPSJB), Chubut, Argentina*
sandra.orlandi@gmail.com

[2]*Universidad Politécnica de Madrid, Madrid, Spain*
diego.manzanal@gmail.com

ABSTRACT: Supervised Professional Practices (PPS) constitute one of the requisites to obtain the engineering degree at the National University of Patagonia (UNPSJB). Students need to develop two hundred hours working under the supervision of two tutors. Both are involved in the activity, only one is directly related with the student. Students can develop their PPS in one of the following ways: externally in a company, internally in a university laboratory, or participating in a research project. The number of students who participate as assistants in a geotechnical research project has increased over time. In addition to that, students participate in the development of papers and present in local and regional congresses. There is a possibility that by working side by side with a researcher, students discover their vocation as researchers. In this way students can develop sensibility in the analysis of geomechanical results and acquire knowledge of local soils, while achieving the requirements for PPS. Engineering instructors and researchers that are involved in this kind of practices select volunteer students for their research projects that allow them to identify problems in the new generations of students, who will become future professionals, researchers or engineering instructors. The research option of PPS thus constitutes a two-way road for researchers and students: the former are improving their teaching skills while the latter are being trained in how to investigate.

Keywords: Research, Assistant researcher, Engineering instructors, Supervised professional practices

1 Introduction

Supervised Professional Practice (PPS) constitutes one of the necessary requisites to obtain the engineering degree in Argentinian universities (Ministry of Education resolution 1232/1, 2001). These practices should have a social outreach (Gallegos et al., 2017) and contribute to the student´s training as a future professional (Ferrari et al., 2013). This requisite was included in the Civil Engineering study programme of the National University of Patagonia (UNPSJB) in 2005. The development of competences in the graduate was being pursued, since they were necessary to be competitive in the continuously changing labour market.

In the current context, the PPS can be fulfilled (in the study course, faculty and university seat of the study case) by choosing among three possible options.
1. External Practice, which can be carried out at a private firm or in a governmental entity.
2. Internal Practice, which can be done by working part-time in the university laboratory (LISHA, Laboratory of Investigation of soil, concrete and asphalt), where studies are performed for external companies.
3. Participating in a research project, performed at the LISHA premises, under the supervision of a project director and co-director. The participation can be complete or partial, depending on the student´s interest and availability. Most of the research projects carried out at LISHA belong to the Geomechanics Field. They are subsidised projects (funded by the Research Department of the UNPSJB or by means

of competitive calls by the National Ministry of Education). The projects are directed and co-directed by researchers who have an engineering post-graduate degree training, particularly specialised in Geotechnics or Soil Mechanics.
The aim of the current article is to highlight the growing interest for participating in research oriented PPS at LISHA shown by the students in the last years of the Civil Engineering degree at the UNPSJB, located in Comodoro Rivadavia.

2 Supervised Professional Practices in Argentinian Engineering undergraduate curricula

Supervised Professional Practices (PPS) constitutes one of the requisites for the Civil Engineering students to finish their undergraduate degree. The requisites are distributed along five years. Within this time, students have to pass 42 (forty-two) subjects, 37 of which are annual or four-month courses subjects, one of them being Geotechnics (annual). The remaining five requisites are: three courses, “Human Resources”, “Communication Strategies” and “Language Accreditation” and two extra requisites: PPS and Final Project.

The minimum time required for the fulfilment of the PPS, according to the Academic Regulations, is 200 hours and the tasks included should involve a relation or connection with the social environment. Accordingly, only research projects that have social aim can incorporate students who need to fulfil their PPS.

An important fact is that only those students who decide on their own initiative to take part in research projects have the opportunity to do so during their study course. This is due to the fact that no subject includes this kind of practices in its syllabus, although many subjects do include laboratory practices in which tests are performed, not for training but for information purposes.

In the study case, the group of researchers who are performing investigation activities are focused on the Geomechanics field: Soil Mechanics and Geotechnics. Other fields, such as Concrete Technology and Sanitary Engineering, carry out research projects in a more reduced way. Not all the subjects in the study course have research lecturers, thus limiting the opportunities for the students.

As already mentioned, the PPS can be fulfilled in three ways.

1. External practices, which can be carried out in a private firm or in a governmental entity. For this kind of practices, the students perform a part-time remunerated job. There is an external tutor who supervises the student´s work and an academic tutor who guarantees that the practices performed correspond to tasks related to the study course. The students sign employment contracts for six months to one year, which are extended in most of the cases. This happens when the interns’ development fulfils the contracting party´s expectations (Garibay, 2002).
2. Internal practices developed at the Soil, Concrete and Asphalt Laboratory (LISHA), where projects for third parties are performed. In this kind of PPS, the students are paid for their job. The practices last at least four months and, in some occasions, students can continue after finishing them.
3. Participating in a research project, as an assistant, under the supervision of two research lecturers. One of the lecturers acts as project director, while the other one is co-directing it. In some cases, the students can be paid with subsidised projects funds. In other cases, they can apply for a scholarship granted by the National Intercollege Board (NIB) in the framework of “The Plan of Strengthening of the Scientific Research, Technological Development and Innovation of National Universities” (Ac. Pl. Nº 676/08 y 687/0) for undergraduate degree students from public universities.

The work involved while participating in any of the options is clearly very different with regards to the premises where it is developed, the tasks that are carried out, the remuneration paid and the certification acquired (Orlandi et al., 2016).

2.1 A tool to reduce the students’ graduation time

A recurring problem in the Civil Engineering degree in national universities, is the excessive time taken by the students to get the undergraduate degree. According to statistics presented in local and regional education congresses, the average time is twelve and a half years. Some authors have tried to identify the reasons through detailed studies and statistics analysis (Das Neves, 2015).

In the study programme, which came into effect in 2005, the PPS became a requisite to obtain the undergraduate degree. The research projects, performed at the LISHA premises, from the Civil Engineering degree located in Comodoro Rivadavia began in 1991, while the first research projects in the Geomechanics field date from 2008. During that year, the first students were incorporated as research assistants, without combining investigation with PPS. The new study programme has the curricular distribution shown in Table 1.

Table 1. Number of hours in Civil Engineering at UNPSJB according to the area of the knowledge (Das Neves, 2015)

General subject	Hourly rate [hours]	Percentage [%]	Minimum hours according to regulations [Res. 1232]
Basic Sciences	1260	30.65	750
Basic Technological Sciences	1065	25.92	575
Applied Technological Sciences	1155	28.1	575
Complementary Sciences	300	7.32	175
Elective Sciences	90	2.18	-
Other exit requirements	240	5.83	-
PPS and Courses*	220		

Note: * “Human resources” and “Communication strategies”

PPS can be initiated by students with the 75% of the study course passed, which only occurs after finishing the fourth year. This is the reason why the incorporation of students who have decided to perform their practices in a private company takes place when they are still studying or taking the exams of final subjects. This implies that when receiving a remuneration, students acquire a certain economic independence. It is very clear to detect that this fact might be one obstacle to finish the undergraduate degree (Das Neves, 2015; Orlandi et al., 2016). Especially in a country where the demand for engineers from all the branches of Science is growing constantly (INFOBAE, 2018).

On the other hand, those students who participate in research projects as part of their PPS or in projects for third parties or at the LISHA premises have a brief and flexible work period regarding time. They can adapt themselves to the intensity of the practices developed and the demand during exam periods (Abate & Orellano, 2015).

2.2 Why does PPS, as complement to research, turn out to be attractive to students?

All the students who have participated in research projects were surveyed before and after their participation in the PPS. The answers before beginning included fear to participate in activities for which they were not prepared. However, by the end of the practices, the confidence acquired to analyse results and detect test errors could be seen.

Some companies, where eventually the already graduated professionals were hired, valued the experience in research. The critical spirit, if it is not innate, requires training through practices similar to the ones carried out in a research project (Abate & Orellano, 2015).

In some occasions, this kind of practices awakened the scientific vocation in the students involved. The possibility of pursuing after graduation a Ph.D., a master´s degree or a specialisation came up almost naturally in some of the student-assistant researchers who had participated in the projects.

The participation in the laboratory practices performed in the frame of research investigation is something to highlight, since the students have co-authored the publication of articles in national and international congresses and magazines, such as:

- S. Orlandi, D. Manzanal, E. Miranda & M. Robinson. “Use of Lignin as Stabilizer in Expansive Soils”, in Proceedings of the 16th PCSMGE, 21-23 October. Cancún, México, 2019. [Miranda and Robinson are the undergraduate students performing their PPS]
- S. Orlandi, D. Manzanal, A. Ruiz, M. Avila & M. Graf, “A case study on expansive clays in Comodoro Rivadavia city” in Proceedings of the 15th PCSMGE. 15-17 November, 2016. Buenos Aires, Argentina, 2015. [Ruiz, Avila and Graf are the undergraduate students performing their PPS]
- S. Orlandi, D. Manzanal, A. Espelet & A. Ruiz, “About the use of soils as backfilling under roofs and flats: two study pathology cases”, Magazine of Geology Applied to Engineering and Environment, vol. 35, pp. 103-114, 2016. [Ruiz is the undergraduate student performing his PPS]

In some occasions, students have participated as lecturers in local Civil Engineering Conferences, encouraging the development, or in some cases the strengthening of presentation skills; for most of them, giving presentations turned out to be a very challenging activity.

2.3 What indirect benefits does the participation in research groups entail for undergraduate students?

Future candidates for graduate courses should appear among undergraduate students. Some of them have clear goals, defined from a very early age. Although a small percentage of students does not have a defined scientific vocation, being part of a research group under the guidance of a committed researcher encourages them to find a new passion for this kind of challenges (Quaranta et al., 2014).

To accomplish this, researchers and institutions are needed to detect these vocations and foster the scientific training (Wesley, 2015), guiding these incipient researching nucleui that are not so easy to maintain over time. The institution where the study case is being developed possesses the required features.

Some of the direct additional benefits for the students which have been detected and fostered over time, are:

- Solving social problems or problems with social impact or generating solutions to problems that have direct impact on society (Álvarez, 2008; Ferrari et al., 2017; Orlandi et al., 2015).
- Developing non-academic skills, such as: team work, oral communication, writing of technical reports, ability to give oral presentations and support ideas, leadership skills, decision making based on knowledge and constant search for information.
- Strengthening of critical and analytical spirit of future professionals.
- Consciousness development about the error analysis from the practical point of view, highlighting the fact that it is also possible to learn from mistakes (Garibay, 2002; Garibay et al., 2008).

Due to the fact that in the laboratories of Argentinian national universities the research projects developed are often at the front end of the national industry, students are trained to become critical future professionals when it comes to interpret the results obtained (Roman et al., 2017). In the case study, the geomechanics laboratory has acquired essential relevance within the study course and the society, becoming a model in the area, not only for its equipment but also for the research lecturers involved.

Due to the limited number of participants in these work groups, the benefits introduced are easy to deploy. The students who choose this kind of PPS strengthen the required aptitude to become responsible, pro-active and analytical professionals, working in a familiar environment, where they have developed their academic training and can find their scientific vocation.

2.4 Candidate profiles

As mentioned previously, the future research assistants in the Geomechanics field are selected among the enrolled candidates during the yearly call issued the last months of the school year. The enrolled candidates are interviewed and considered according to their expectations, skills and personalities. They must have time availability of at least 9 to 12 hours weekly for a period of one year. During partial and final exams, the students are allowed to miss the practices.

Balanced work groups from the beginning promote suitable dynamics for team work. Common interests favour the exchange of ideas and respect towards other´s opinions. Indeed, strongly different characters may create a hostile work environment in which tests must be done repeatedly and the results obtained must be questioned permanently.

Unpaid research work groups, according to the authors' experience, require a delicate balance between the members of the team. Paid research groups show the same weakness, since the remuneration is typically low in these projects.

Historically speaking, from the beginning of this kind of practices, two students have abandoned the project in which they were working. In both cases, it was due to financial issues. There is no record of cases of abandonment due to problems in the group. With regards to group formation, at times it was necessary to rearrange it in order to ensure the success of the practice.

The number of students of each call depends on different factors: number of research projects, researchers involved and students who have applied.

2.6 Competences: one of the professors' motivations to develop these activities

The process that a student undergoes during a PPS as a research assistant takes around two months of work, shared between the director and the co-director, for any student who is finishing the PPS.

The learning sequence includes the management of standards (IRAM, ASTM, VN) associated to each test, the design and management of a spreadsheet and the preparation and sampling for the test tube shaping. To fully understand the work, students are given some articles to read and present to the rest of the assistants (Santamarina, 2015). The first phase of the PPS requires a lot of dedication from the research lecturers, training and working together with the incoming students. After this period, less presence but more control over the result is required (Montano & Yasbitzky, 2017), together with training and assessment.

The researchers pursue the following objectives through this kind of practices (Atkinson, 2012; Kindelan et al., 2008; Roegiers, 2007)

- Ability to perform geotechnical tests.
- Autonomy to solve everyday situations at a geomechanics laboratory.
- Ability to present their projects during dissemination events (Kindelán & Martín, 2008).
- Acquisition of knowledge and consciousness of soil problems in the area, which originates most of the pathologies found in civil engineering works.
- Strengthening the technical writing by means of reports including the data used to write scientific dissemination articles.
- Team work developing leadership.
- Ability to be proactive.

One of the main challenges the professors come across when teaching to new generations of students is the lack of interest. Keeping the youth motivated is possible, according to personal experience, if curiosity and challenges are used as tools. Everyday work creates discouragement; however, error analysis and searching for the cause of errors usually create motivation if it is well stimulated (Sampieri et al., 2014).

This kind of practices requires previous organisation, for which the research lecturers must be trained permanently (Garibay et al., 2008). Each new group will have a different dynamic, which will necessitate customised organisation approaches. This forces the researcher to be alert permanently to the needs of each new generation of students.

3 PPS research projects at UNPSJB

Since the first research project related to Geomechanics in 2008, the number of students who were incorporated as research assistants has grown. From the year 2014, the students started to participate in the projects as part of their undergraduate training completing the PPS. As mentioned previously, this number depends principally on the number of researchers who carry out these projects. Therefore, as long as the number of research lecturers grows, the number of projects and students involved is

expected do the same. Presently, the professors are focused on the training of new researchers, who are starting their Ph.D. and trying to find new candidates to enrol in a Ph.D. program in the students' groups with whom they are working.

In Table 2, the students are divided into four groups. Group I includes the students who began their studies before 2005, when the Civil Engineering curriculum changed, and, hence, do not have as a curricular requirement the completion of PPS. The remaining three groups are students who have a curricular requirement to complete the PPS. They are divided between those who choose to do it in the framework of a research project (group II), those who do it as a professional practice in the LISHA Laboratory dependent on the faculty and Engineering (group III) and those who do the Supervised Professional Practice outside the university, either in a public department or in a private company related to civil engineering as external practice (group IV). The options "external practices" and "working part-time at LISHA" have variable demand according to the local economic situation. On the other hand, considering the growing demand for engineers and the low rate of students over the years, these two options compete to attract students before they graduate (INFOBAE, 2018).

Table 2. Statistics of the number of students and selected options to accomplish with the PPS

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	total
(I)	1	5	1	3	5	4	5	2	3	1	0	1	0	0	0	32
(II)	0	0	0	0	0	0	0	0	0	0	2	2	3	4	4	15
(III)	0	0	0	1	0	0	0	0	0	1	4	4	2	13	2	27
(IV)	0	0	0	0	0	2	1	0	0	1	0	4	4	1	1	14

(I): Student without PPS requirement (Student enrolled prior to 2005, when the Civil Engineering curriculum changed and PPS was incorporated).

(II): Research project as PPS.

(III): Working part time at LISHA (Laboratorio de Investigación de Suelos, Hormigones y Asfaltos).

(IV): External Practice Students.

In the study case, the working areas involved are: unsaturated soil mechanics (specifically compact and not compact expansive soils), sand used for fracking and CO_2 injection in rocky formation. These thematics have a high social impact in Argentina. The research projects have produced articles in local congresses (Civil Engineering Congresses 2016 and 2018 and Geology 2019), national congresses (CAMSIG 2016, 2018), national magazines (Argentinian Magazine of Geology applied to Civil Engineering, ASAGAI and Argentinian Magazine of Engineering Deans, CADI), Latin-American Congresses of Soil Mechanics (PANAM XVI and XVII), and the latest international congress of Rock Mechanics (ISRM 2019)

Moreover, the study case developed in the current article has been presented in national and Latin American congresses in scientific-technological degrees (IPECyT 2018) and in the Argentinian Congress of Deans from Engineering Faculties and Engineering training (CADI 2015 and CAEDI 2018).

From the first student incorporated in 2008 up to now, 21 students have participated as assistants, from which 14 performed their PPS, 2 abandoned the practice, 1 is studying for a Ph.D. supervised by a European University, 2 students who are about to obtain their degree are considering options to start a Ph.D., 2 students were granted a scholarship, 4 students received remuneration from funds from subsidised research projects, while 2 research lecturers were in charge of all the student participants. Likewise, directors and co-directors of research projects were the ones who incorporated the PPS and were responsible for the publication and presentation of technical articles on magazines and congresses.

Regarding the groups of testing in which the students have acquired and are continuing to acquire new skills (Atkinson, 2013) the following can be mentioned:

- Soil classification;
- Determination of volumetric and gravimetic properties;

- Test tube shaping;
- Oedometer test;
- Cutting test;
- Determination of swelling pressure through different tests: oedometer test, expansion under controlled swelling pressure, swelling pressure using standard ASTM, Lambe test;
- Retention curve using the filter paper method;
- Unconfined compression test;
- Triaxial tests: UU, CU and CD;
- Linear contraction;
- Permeability of variable charge permeameter;
- Specific Surface using the methylene blue method.

The incorporation of a bigger group of tests has been considered, yet its fulfilment requires more supervision, which explains the delay in its implementation.

4 Conclusion

The PPS needed to obtain the Civil Engineering undergraduate degree located in Comodoro Rivadavia, at the Engineering Faculty of the UNPSJB, performed through the participation in a research project, constitutes practically the only option for undergraduate students to participate in research projects.

The work developed by students in the Geomechanics field during a PPS helps them acquire knowledge that can be applied by them as future engineers, including the ability to perform geotechnical tests and the determination of design parameters, the identification of problematic soils, as well as the development of technologies that can be applied in local industries. The students also strengthen general skills they will need along their professional life, such as technical writing, oral communication, autonomy, decision making, leadership, team work.

The development of PPS takes place inside a work environment, in which they are immersed from the beginning of their study course. This fact allows to reduce the time needed to develop the activity. Hence, students can obtain their undergraduate degree in a time shorter than the average, which is about twelve years for engineering degrees in Argentina.

The researchers who participate in this kind of practices are interested in forming permanent work groups, where students take part in investigations, fulfil their PPS, are trained in the Geomechanics field and are thus able to better choose whether to continue their education by enrolling in a Ph.D. program or to look for a professional employment. The process at UNPSJB began only fifteen years ago and it is not totally established yet. Indeed, a greater amount of researchers completely devoted to attract Ph.D. students is needed, as well as a higher number of research projects in which more students could be participating.

While this is happening, it is the opinion of the authors that the undergraduate students who have already had the opportunity to participate in a PPS end up their study course better prepared to face professional challenges, equipped with not only technical but also attitudinal knowledge that will clearly make a difference among their peers. Likewise, this tool allows the possibility of creating a link with the society they are immersed in, looking for solutions for social needs through their projects.

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Authors' bios

Sandra Orlandi, Universidad Nacional de la Patagonia San Juan Bosco, Argentina

M.Sc. Sandra Orlandi was born in Comodoro Rivadavia, Patagonia, Argentina. She graduated as a Civil Engineer at the Universidad Nacional de la Patagonia San Juan Bosco (UNPSJB) and subsequently did her Maestría en Ingeniería at the UNAM (Universidad Nacional Autónoma de México), where she specialized in Geotechnical Engineering and Geomechanics, working with Prof. Gabriel Auvinet. She is currently doing her Ph.D. at the Universidad Nacional de la Patagonia San Juan Bosco, working with Prof. Diego Manzanal. She is an assistant professor and consultant at the UNPSJB. Her main technical areas of interest are the behavior of highly expansive soils, soils improvement with polymers, forensic geotechnical engineering and foundations. She is working for the last ten years with Dr. Diego Manzanal in several research projects involving undergraduate students. Both share a passion for research-based geotechnical education.

Diego Manzanal, Technical University of Madrid, Spain

Dr. Diego Manzanal is an assistant professor at the Technical University of Madrid (UPM) who specializes in the field of Geomechanics. He holds his Civil Engineering degrees from Universidad Nacional de la Patagonia San Juan Bosco (Argentina) where he is visiting professor. He obtained a Master degree at Geotechnical Laboratory at CEDEX (Spain) and his Ph.D. at UPM. His research interests involve the constitutive behavior of geomaterials (soils, rocks, cement) for different geotechnical and geomechanics applications. His involvement in research education on civil engineering focuses on project-based learning.