CHAPTER 19.

LEARNING CAREERS AND ENCULTURATION: PRODUCTION OF SCIENTIFIC PAPERS BY PHD STUDENTS IN A MEXICAN PHYSIOLOGY LABORATORY: AN EXPLORATORY CASE STUDY

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This institutional case study[1] presents evidence on dimensions of the *learning careers* and *professional enculturation* of Spanish speaking physiology PhD students in a public research university in Mexico from the perspective of professional communication and genre learning in English.[2] Study data sources were interviews with students, heads of laboratories and thesis advisors. The study reported here is part of a larger research project (Kent, Carrasco, & Velázquez, 2009) ongoing since January 2010 in several additional disciplines: astrophysics, biotechnology, agriculture, oceanography, materials science and nanotechnology carried out in several Mexican research institutions. As explained in more detail below the study seeks to fill a gap in the literature on career enculturation processes in L2 contexts through the theoretical lens of *learning career.*

STUDY BACKGROUND

The scientific PhD is a recent development in the Mexican academic system. Historically scientists were trained in some disciplines in the National University but mostly abroad. In 2008 there were 7,000 students enrolled in 348 PhD programs in the natural sciences, health, technology & agriculture. Between 1995 and 2006, the number of yearly graduates in these disciplines grew from 520 to 2,650 (SIICYT, 2008). This growth has occurred in the context of a

greater number and diversification of research and training institutions. National policy on science and technology has focused strongly on supporting and evaluating the scientific PhD. There are scholarship funds for accredited PhD programs as well as a developed evaluation system for these programs. Excellence and internationalization of the scientific PhD are vital policy objectives.

The endogenous expansion and disciplinary variation of the scientific doctorate are evidence of a self-sustaining dynamic of the Mexican science and technology system, and the PhD is its main instrument for generational reproduction as well as an important site for new knowledge production, through the research-teaching-learning nexus (Clark, 1993). Doctoral programs are, thus, part of a complex institutional and cultural web of expectations, funding, reputational competition and regulations.

This chapter reports on fieldwork in a physiology laboratory in a large public university in Mexico in May 2010. In our ongoing research on various dimensions of training experiences of Mexican doctoral students in the sciences (Kent et al., 2009), one focus of interest is the analysis of their production of academic texts. Following on the idea that "communication is the life-blood of academia," Becher and Trowler (2001, p. 104) point out that "knowledge production (the principal cognitive question) and the establishment of reputations (the key social consideration) necessarily depend on it." Gaining recognition is a major motivation behind scientific publications, and high impact journals are especially sought out by researchers in their struggle for authorship (Carrasco & Kent, 2011). Overington (1977) states that a scientist is recognized as to the extent that he or she becomes an author, a basic fact of scientific life that was clearly pointed out to us in interviews with research physiologists:

> Our doctoral students understand that if they don't publish, they won't graduate. And later on in their career, if they don't continue publishing they will end up teaching biology in high school (P1).

On the basis of Prior's (1998; 2006) perspective of writing for scientific recognition as a literate activity whereby participants co-produce texts and construct their disciplinary identities, we explore practices of Mexican, Spanish speaking researchers and PhD students in their efforts to express experimental results in written form and to submit them in English to specialized journals.

Central to our study are the theoretical concepts of *learning careers* (Bloomer & Hodkinson, 2000, p. 591) and *enculturation and apprenticeship* (Delamont & Atkinson, 2001, p. 96) and how these theories are seen in terms of *professional communication* and *argument formation* in writing for scientific publication

(inter alia, Bazerman, 2006; Newell, et al., 2011; Prior, 2006). These three areas are presented below to form the theoretical framework for the study methods and interpretation presented later on in the chapter.

Learning Careers and Transformations

From the perspective of *situated learning,* i.e., learning as a social practice bound within social contexts, Bloomer and Hodkinson (2000, p. 591) offer the concept of a *learning career*. The term *learning career* refers to the development of dispositions toward learning over time. It takes many forms in different contexts. In their carefully constructed theoretical framework, Bloomer and Hodkinson (2000) review studies that include theories of learning which position learning as situated in a context in which the learner, the activity and the context work as a synergistic triad of elements leading to learning and therefore transformation. As they explain, this perspective regards learning from a constructivist worldview, represented by flexible dispositions influenced by the context-dependent or social construction of personally held schemata. The authors give prominence to social interaction as the generating force of the schemata or meanings learners give to their experiences. Further social interaction generates and refines the schemata in an ongoing, ever changing process (Bloomer & Hodkinson, 2000, p. 589).

This argument is compatible with Blakeslee's point (1997, p. 126) that a student's training trajectory as a future scientist involves learning as a situated construction. The learner-apprentice is guided by an expert in engaging in activities considered typical by the discipline. He/she learns, develops and uses specialized knowledge through his/her participation in specific disciplinary activities, contexts and cultures.

Such intense engagement implies commitment and even passion on the part of the novice. In the absence of strong emotional attachment, it is hard to see how deep absorption in everyday activities in a laboratory may be sustained during the period of four years, required minimally for doctoral completion. Such absorption may lead to *transformation.* Bloomer and Hodkinson (2007) use the term *transformation* rather than change or transition because of the notion of career and the construction of the career identity of the person. It is the learning career as a situated social act that leads to the transformation (p. 590).

If knowledge is co-produced through intense activity in a specific institutional context and disciplinary culture, it is because students are progressively transformed from inexperienced newcomers or "novices," to apprentices and finally to independent researchers (Laudel & Gläser, 2008; Parry, 2007). This change in identity involves the development of autonomy in each PhD student,

which is an expected, although often implicit, result of the whole process and is the result of a complex rite of passage (Laudel & Gläser, 2008). This progression is the subject of the following section, which presents another axis of our theoretical framework for understanding the professionalization processes of the PhD students in our study.

Enculturation, Apprenticeship and Tacit Knowledge in Laboratory Science

Thus, a PhD student goes through a process of enculturation in pedagogical forms and interactions that occur in a laboratory context (Delamont & Atkinson, 2001). Bazerman (2006, p. 223) reminds us that the

> ability to understand the genres of academic disciplines—including the kinds of roles and stances one adopts, interpretive procedures, forms of contention, and uses to be made of the texts—is the result of substantial enculturation and apprenticeship that makes these odd and particular forms of communication familiar, meaningful and intelligible in detail and nuance.

The micro-social setting of laboratory science constitutes a special type of intellectual and material working environment for scientific apprenticeship and enculturation (Knorr-Cetina, 1999; Latour & Woolgar, 1986). In their study of graduate students in biochemistry and geology, Delamont and Atkinson (2001, p. 96) report that

> PhD students describe the research group as a mutually supportive environment in which ideas and materials are shared on an everyday basis. Even where members of the group work on different research problems, there are overlaps in the materials, equipment and techniques, which they use … The research laboratory operates upon the principle of reciprocity whereby members take an active interest in the activities of their colleagues. … Doctoral supervision is therefore understood by team members to be a shared responsibility (p. 98).

Other scholars, however, stress the hierarchical nature of traditional apprenticing relationships between supervisors and students (Blakeslee 1997, p. 126), since the transmission of authority implicitly accompanies the co-production of

knowledge. It seems sensible to suggest that, in laboratory settings, both norms of hierarchy and reciprocity are present.

This type of continuous interaction is the significant context for the appropriation of the tacit skills crucial to laboratory science, skills that are not seen as "teachable" or even particularly "learnable." They cannot be translated into standard formulae but must be grasped in practice and are even talked about as a "gift" (Delamont & Atkinson, 2001, p. 100). Thus, enculturation is built on the practical experiences of apprenticeship. Tacit knowledge is taken up through the apprenticeship mechanism, i.e., membership in the socio-cultural context of, in this case, the science laboratory. This kind of learning is characterized as being "*caught* rather than *taught,* transmitted through personal experience rather than by systematic instruction. … It travels best where there is personal contact with an accomplished practitioner and where it is already tried and tested" (Delamont & Atkinson, p. 100, emphasis in original).

Analogously, the appropriation of literate practices in science by students may occur obliquely. Prior (2006, p. 64) declares that, as sociocultural research on writing has revealed, "much of literate activity is implicit and learned implicitly." This is the focus of the final axis of our theoretical framework explained in the following section.

The Role of Communication and Genres in Career Learning

An important aspect of specialized literate activity is the construction of arguments following institutionally established rules. Here, argumentative reading and writing do not refer exclusively to logical reasoning and "winning an argument" but to relationships built on social practices. These practices not only establish group solidarity but form the "material structure, space, and organization of a particular literacy event" (Newell et al., 2011, p. 288).

We understand this research to be informed by two complementary perspectives on academic literacy as a social process and situated cognition: *New Rhetoric Theory* and *Social Genre Theory.* Going beyond traditional rhetoric theory, which presents argumentation as a resource for persuasion or engaging in debate (cf. Bazerman, 2006), new rhetoric theory emphasizes one's relationships with an audience on the basis of shared beliefs or attitudes (cf. Newell et al., 2011). The audience provides a motivational context for writing but also legitimates types of arguments around and through which students must find their way in their literate development.

A related aspect of specialized literate activity, from the perspective *of Social Genre Theory,* is students' grappling with appropriate genres that disciplinary

communities recognize as valid for specialized communication (and mutual identification). Bazerman (2006, p. 222) provides a point of departure for understanding genre as "complex signaling of mutual intelligibility" because "most texts sit in among other texts or with few external orientation clues. The reader and writer need the genre to create a communicative meeting place legible from the very form and context of the text." PhD students in the sciences must learn to read, write and speak *disciplinarity* (Prior, 1998) within established genres, such as journal articles, conference presentations, letters, and reviews, among others.

It is within these actions that we examine a cohort of laboratory members—experts and apprentices as they negotiate learning careers and enculturation processes in initiating and being initiated into their professional communities. Specifically the study looked at i) writing production as *learning career, ii)* processes of enculturation, apprenticeship and tacit knowledge in laboratory science, and iii) communication and argument formation in career learning in the research location as described in the following section.

METHOD

Study Context

The research site, a physiology institute of a large state university in central Mexico, was established in 1983. It was one of the first research institutes created on a separate footing from teaching departments in this bureaucratically and politically complex university. In this context, it is no small feat that the institute has been able to establish autonomy in its local management and an integrated cosmopolitan research culture with a collegial ethos. The institute operates with 16 full-time researchers who work in six labs. The work carried out by researchers at the institute, in neuroscience, cardiovascular, and cell biochemistry, is recognized by their publications in specialized journals and their participation in national and international networks. The faculty has one master's and one PhD program. We interviewed professors and students in four labs as described below.

Participants

The interviews were carried out by one researcher and two master's students associated with our project in May 2010. For this study, we interviewed five physiology researchers, including two women and three men. Three of them were founders of the institute, and two were graduates of the institute's doctoral

program. All researchers who were interviewed were at the time of the study in charge of their own labs.

Table 1. Academic staff participants (*n*=5)

I	Description	Career level	Gender
P1	Vestibular studies LAB 1	Founder of the institute	Male
P2	Vestibular studies LAB 1	Founder of the institute	Female
P3	Central nervous System LAB 2	Graduate of the institute	Male
P4	Cardiac studies LAB 3	Founder of the institute	Male
P5	Neurobiology LAB 4	Graduate of the institute	Female

Six PhD students associated with these labs also participated. Semi-structured interviews were used as the principal data collection method.

Table 2. Doctoral student participants (*n*=6)

ID	Description	PhD program level	Gender
S1	LAB 1	Advanced student	Female
S2	LAB 3	Early career	Male
S3	LAB 2	Early career	Female
S4	LAB 2	Advanced student	Male
S5	LAB 1	Advances student	Female
S6	LAB 3	Advanced student	Male

Taped interviews were transcribed and later codified and analyzed using Atlas.ti (ver. 5.2).

RESULTS AND DISCUSSION

This section reports the findings of the study interpreted within the framework set out above particularly within the concept of *learning career.* The findings are presented around the three theoretical areas put forward above:

1. Writing production as *learning career*
2. Processes of enculturation, apprenticeship and tacit knowledge in laboratory science
3. Communication and argument formation in career learning

Excerpts are presented exemplifying the comments from participants identified as either professors/researchers (P1, P2, P3 …) or as PhD students identi-

fied as (S1, S2, S3 …) (see Tables 1 and 2 above). The excerpts were translated from the original transcripts in Spanish.

Writing Production as *Learning Career*

Situated learning takes on several forms in different contexts. In a physiology lab, according to P4.

> Students live here, so tutoring happens constantly on a daily basis, for at least one or two hours. Students spend their lives in here. They get totally involved with the experiment. I'm not on top of them all the time, but if they have questions they come to me. Sometimes I tour the lab and ask them how things are going. This is what we do every day.

In addition to preparing and defending a thesis, to obtain a PhD in physiology the student must publish two journal articles. The principal author of a paper is the person with primary responsibility for developing an experiment and reporting findings, although this often occurs in collaboration with other researchers. A student must learn to initiate, manage and conclude this process successfully.

A professor talks about the responsibility this entails:

> All experimental results, all the data, are the responsibility of the student. I hold her responsible for delivering all processed findings. She delivers them to me, in tables and graphs or figures, and then we initiate a discussion. This is a conversation. I collaborate with the student in generating her results. (P2)

Students also refer to these interactions as conversations:

> Well, I feel that in the informal chats with my advisor we get interesting ideas … he thinks of something, tells me about it, asks me to get more data. And then I come out with a hypothesis, the articles I've been reading. It all happens in the lab, in small groups … (S1).

If a thesis advisor is able to state clearly what is required from a student, he is in a position to provide valuable guidance. This guidance has different focuses. One is requiring students to have a good grasp of the state of the art of their research topics, pointing out the important names and journals. This is not only

a question of managing content but also of familiarization with typical models of publications or genres. When, further down the line, the student begins writing, these models play an important part.

From the perspective of a student, it is not different:

> My advisor is present in all things … in an experiment, he says "look, I suggest you do it this way" … in writing stuff, he'll even show you how to write … "you'd better correct this." … He's really attentive to our results … he'll suggest "Try this kind of analysis" … or if things didn't work out, he'll suggest another way of going about it. (S2).

Collaborative Practices in Developing Genres Recognized by the Discipline: Enculturation and Apprenticeship

Working in the lab and learning to produce texts go together. Initially, students work on professors' manuscripts, but this occurs in a collaborative environment in the lab where advanced students help newcomers as well. One apparently significant transformation is the student's transition from individual work to collaborative work in the lab:

> Teamwork is very important for us, a student must be able to work with others, with three or four other students with whom he/she must coordinate to carry out experiments. (P3).

Living in the lab, working intensively and writing with others constitute key learning experiences for doctoral students, and, as Delamont and Atkinson (2001) point out, this context is crucial for developing tacit competencies through observing others and learning vicariously from them.

Similarly, a student compared his lonely experience as a masters student in a physiology lab in the United Kingdom with his current experience, now as a PhD candidate, in the Mexican lab:

> Here we've been told from the beginning that we're a team, we have to help each other, we have to work for the benefit of the lab. This is really different from my masters studies in the UK, where everything was more private, everybody working on his own . . it was actually weird for somebody

> to help out another student … OK, it's a very large lab with students from all over the world, so you didn't get the feeling of belonging [to a larger endeavor] … Here, although we each have our own projects, we're a team following common goals. (S2).

Helping others and receiving guidance from them are accepted as natural practices in this lab, as one PhD student expressed it:

> Sometimes you get an undergraduate student coming to the lab, sitting down with you to see what you're doing. So you explain, this is how you do this and that. … We all get to be observers in others' experiments. … So, at the beginning you're just a spectator but then you learn stuff that you pass on to others. It's really important to have somebody watching you, questioning stuff you probably didn't observe on your own. (S3).

Another student emphasized that a collaborative working environment was very important for her initial induction to the PhD program, becoming a member of the team.

Clearly, collaboration is not only a common practice that has evolved "naturally" as a normal form of social interaction in this lab culture. Teamwork is a crucial practice for carrying out complex tasks in the lab, as pointed out by one student:

> Collaboration is important, like when I have to perform a surgical procedure, I can't do it alone. Some experimental procedures require working together with someone else. (S4)

Collaboration is an objective necessity in lab work in physiology, where instruments, procedures and analysis necessitate several hands and eyes (Latour & Woolgar 1986; Knorr-Cetina 1999).

In addition to working collaboratively on experimentation, researchers also write in collaboration. Most texts are authored collectively, with five or six coauthors.

> If a student appears as first author, it is because he was in charge of the research. Other students may appear in the author list or else as collaborators, depending on the importance of their collaboration, whether substantive or procedural. (P4)

This statement by a professor is confirmed by a student:

> All or most publications are collaborative. In our lab, the research director may appear as the last author and the student as first author. We may even include collaborators from other labs. (S5)

Co-authorship is a standard practice that students assimilate from the beginning of their masters and doctoral studies.[3] Journals accept unlimited numbers of authors and allow the authors' list to be changed in the course of revisions.

Importantly, researchers early on become accustomed to the various genres required by journals.[4] Students initially become aware of established genres and forms of argumentation when they carry out literature reviews. Later on, when they prepare texts for publication, they pay attention to instructions usually provided by journals for prospective authors. "We make sure our students look at these instructions and have them try to follow them," says one professor (P4).

The Perception of Audience and its Relationships with Writing: Communication and Genre Learning

A crucial decision in the doctoral experience is defining a research problem within a specialized area of the discipline. Students spend significant amounts of time studying the relevant literature on their respective research problems. One professor states:

> I give each student a list of articles related to their topics, which they must read and discuss with me. … They must also produce written reports on these reading … like reviews. Once this literature is well known by the student, we can proceed to define specific research questions for experimental procedures. (P5)

The student is made to understand that her research must add to existing knowledge. This fund of knowledge must therefore be read, reviewed and understood.

The literature review serves other purposes. In the course of the effort of becoming familiar with the names, the methodologies and the findings that are relevant to their specializations, students not only explore established genres but also develop an identification with "invisible networks" of scientists whose articles they are reading (Fortes & Lomnitz, 1991). Initially, this is one-way identification: the student begins to express herself using the specialized termi-

nology and naming the authors she deems important (or those deemed important by her advisor).

Interacting with a scientific audience, however, starts out concretely within the lab at the beginning of doctoral studies. The student's initial audience is represented by their direct advisors and other qualified researchers in the lab. One student says:

> I'm about to make a presentation of my thesis proposal to the researchers in the institute. It must be a three-year project, with clear objectives. I have to convince them that I've read enough to understand what I'm doing. … (S2)

A second student pointed out that he first worked on his proposal with two thesis advisors, before making a presentation to the institute's research committee. It is interesting to note that he uses the first person plural:

> We [his two tutors and himself] have to defend this proposal before the committee … whether it's interesting for the lab … we get comments on method, timing. … . (S6)

Further on in their work, students travel to conferences to make their first presentations before a wider audience:

> Well, I guess we all want to attend conferences … I mean, what's the point of working so hard in the lab if nobody's going to find out what you're doing. (S3)

At this point, it would seem that, beyond merely complying with an academic requirement of the doctoral program, conference presentations emerge as a necessity for the student, who begins to feel the need to communicate with a wider audience to justify his work in the lab. Communication of results emerges as an existential necessity for a budding scientist.

A professor points out that conference presentations may be papers or posters. She feels that student newcomers are more comfortable initially with poster presentations.

She states that conferences are means by which students become familiarized with academic models of communication and evaluation:

> We're very focused on conference presentations, both locally

> and internationally. Every year we send papers to the International Conference of Neuroscience and the National Conference of Physiological Sciences. This allows us to see whether our work measures up. (S5)

Before travelling to a conference, students and professors have seminar sessions where papers are presented and discussed.

Writing for an international public means writing in English (Buckingham, 2008; Englander, 2011). One head of a lab stated that it is desirable at the very least

> for students to read English and write well in Spanish. Our students come to us with deficits in reading and writing [in their native Spanish]. (P4)

Research directors monitor their students' writing of first drafts in Spanish, which are also read and commented on by student peers. A student said

> My advisor supervises all our publications and in fact we publish through him. We sort of write up the introduction, the materials, the methods and the discussion. Then he reads it and makes a lot of corrections.(S3)

At that point the Spanish version must be translated to English. Some established researchers do this work themselves. They then reach out for assistance in improving their written English. For example, says one student:,

> Some investigators rely on external consultants. My advisor knows somebody who works for Scientific American in style and grammar correction. He sends his papers to this guy before submitting it to a journal. (S4)

Students must learn written and spoken English, but they also learn that not all scientific language is textual. A professor points out that

> when our students go to conferences they find people from all over speaking in English … at first students only understand half of what's going on … but then they see presenters using images … and this helps a lot. (P2)

Standardization seems to be an aid in L2 writing. Learning to write specialized English is in a way facilitated by the standardized genres, structures, styles and specialized vocabulary employed by scientific journals.

CONCLUSION

> Transformations in learning careers take many forms. They are not predetermined, although they are oriented by the habitus of the individual and by the material and cultural contexts within which the habitus has developed and the person is located.(Bloomer and Hodkinson, 2000, p. 591)

From the findings two aspects stand out: i) learning to produce texts by working initially on professors' manuscripts, and ii) a collaborative environment in the lab. Although the responsibility for carrying out an experiment and preparing a paper fall to one student, this is done collaboratively, following several moments that we were able to glean from the interviews:

1. The literature review: searching bibliographic databases available online from the university library.
2. The production of experimental data.[5]
3. The analysis of the discursive models required by journals. Preparing a draft for discussion among researchers and fellow students in the lab.
4. Preparing and making presentations at conferences.
5. Further drafts are prepared by the author-student with the assistance of corrections and suggestions made by her student peers who make annotations using Microsoft Word's tracking control function.
6. Translating the text to English.
7. Submitting the text to a journal and rewriting it when necessary.

These moments are reported by students and professors as the standard steps toward publication and, hence, a successful PhD. The changing dispositions toward learning that underly this process are perceived as a *normalized* (Starke-Meyerring, 2011) series of stages to be followed. A student pointed out that this kind of work helped her to understand the *steps she must follow* to do written reports: where to start, where to search for data, and how to carry out analysis. However, this progression actually involves complex processes of induction, interaction, teamwork, genre learning, co-production and presentation to specialized publics. Identifying and learning to use specialized genres are central this development. It is interesting to note how the perceptions of its practitioners translate this mani-

fold experience of transformation from a newcomer-apprentice to an autonomous scientist, i.e., a validated professional, into a straightforward trajectory. Standardization, in genres and in self-perceptions, seems to cover complex and multifaceted scientific practices with a "cloak of normalcy" (Starke-Meyerring, 2011) that contributes to stabilize and legitimate the research enterprise. But, seen from the perspective of the learning career, a PhD student in physiology brings into play multiple dispositions that develop in the working context of the lab.

NOTES

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2. We want to express our gratitude to Paul Rogers and other readers for their comments and support in revising previous drafts of this text.

3. This lab has both master's and PhD students working together and often includes students from the schools of medicine and biology.

4. The most highly valued genres by our interviewees are research articles, brief communications and reviews. Simple and direct writing is valued by editors and reviewers, a fact that is not often grasped initially by students and which they must learn.

5. This expression is too facile, glossing over extremely complex and time-consuming activities in a lab: preparing an experiment, executing it, and collecting data.

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