An ethnographic approach to understand the role of graduate studentsin the production of knowledge in science laboratories

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Abstract

Knowledge production in science is very often confined to the outcomes that the corresponding discipline presents through publications (textbooks, papers, monographies), and scientific events. Both hard and soft sciences – as we know them – work in their own domains. Science laboratories are entities or places where these practices take place. The ways how scientists interact among themselves, with tools or artifacts can be described in terms of the contributions made by 'ethnography' or a written report on how a group of people interact towards a particular purpose. Precisely, this is the goal of this article as far as it accounts for how science labs serve as 'learning environment' (LE) for those who work there: scholars, graduate students, technicians and peers. It is also emphasized a discerning look on how an 'ethnographic frame' (EF) provides a learning experience as developed in a lab setting. As such, by getting a deeper understanding of the people there (scientists, graduate students, assistants, etc.) science educators can benefit greatly from an ethnographic study in order to promote science learning, scientific knowledge, and – why not – improvement of teaching strategies toward genuine motivations for students, prospective scientists. By knowing how scientists work in their labs we can promote these types of practices in an educational system.

Key words: ethnography, knowledge, approach, learning (setting) environment, cyberspace.

Resumen

A menudo la producción del conocimiento científico lo encontramos confinado a los resultados que las distintas disciplinas científicas dan a conocer vía publicaciones (libros, artículos en revistas de divulgación o especializadas) y participaciones en congresos o seminarios. Tanto las ciencias 'duras' como 'blandas'- como las conocemos – trabajan en sus propios dominios. Los laboratorios de ciencias son entidades o lugares donde se realizan las actividades o prácticas de una ciencia. La forma cómo interactúan los científicos, entre ellos y con los artefactos propios de un laboratorio se pueden describir y estudiar mediante una 'etnografía' o informe escritos, con una estructura específica, sobre la manera o forma en que actúa un grupo de personas con un propósito determinado. Esta es una de las metas de este trabajo el que da cuenta sobre cómo un laboratorio científico constituye un ambiente de aprendizaje para quienes lo integran. También se enfatiza la importancia de ello como un 'marco etnográfico' (ME) tal que provee experiencias de aprendizajes. Como tal, al tener una comprensión más profunda de lo que ocurre en un laboratorio, son los profesores de ciencias los que más se pueden beneficiar con los aportes de un EE para promover mejores aprendizajes de la ciencia y despertar también mejores motivaciones por aprender ciencias con miras hacia la formación de científicos en el desarrollo de un país. Conociendo cómo trabajan los científicos en un laboratorio podemos incentivar estos tipos de prácticas en un sistema educativo

Palabras claves: etnografía, conocimiento, acercamiento, ambiente de aprendizaje, ciberespacio.

Introduction

In the last two or three decades there has been a growing body of literature thatuses an ethnographic frame to understand the production of knowledge in science laboratories. Considering that Chile is an emergent economy and a member of OECD, it is imperative to promote careers in science both at the undergraduate and graduate levels within our national universities. However, in the field of science education at the tertiary level the learning process and experiences of graduate students of 'hard sciences' have not been addressed with propriety. In this article, my aim is to address and clarify the following questions: a) how has such research described the role of graduate students in their laboratory lives and how they have experienced their stay in the laboratory; b) how might laboratories serve as learning environment for those who work there (in this section, I include examples of the types of things that scientists learn through lab work as well as the processes); c) what particular insights does an ethnographic frame provide about laboratories as learning environments as contrasted with other research approaches, and, what are some of the problems and challenges that come up when using an ethnographic approach (hence EA).

The answers indicate that the EA raises three particular insights when looking at those settings as learning environment: knowledge about how individual members of a laboratory solve particular problems; understanding how the more experienced or expert members of a laboratory socialize with those less expert members about scientific practices; and, understanding the laboratory in its role as a promoter of science learning. Derived from these insights some challenges that the ethnographer must take into account emerge: the degree of engagement in daily lab activities, the amount of science contents required when interviewing a scientist, the ability to focus on one aspect of the lab's ongoing activity, the ability to be physically and virtually in several fields, and the skills involved in constructing a scientist's life in the laboratory when writing one's report.

An ethnography, then, is the result of a participant observation that, when used within the contexts of the aforementioned challenges, helps greatly to understand better how graduate students in different laboratories are able to learn. The outcomes could also help science teaching promotion throughout the educational system to guide school administrators, teachers, and scientists to improve curricula both at the undergraduate and graduate levels. It is a useful tool which provides feedback to the different self-assessments and accreditation processes ininstitutions of higher education within the framework of accreditation and design of sound methodologies for the teaching of science; it is a pressing need to go through a process of this sort. In other terms, we need to have a deep understanding of the learning processes that take place in a lab setting, and, in the long run, to foster interest in scientific careers: our country, Chile, cannot afford to be only an spectator anymore.

The role of graduate students and their lives in a science lab

Graduate students are always regarded asnovices who have to learn practices, values, and norms related to their position in a laboratory (Latour, 1983). By learning these values and norms, they will eventually become 'scientists'. A graduate student must develop or forge an identity as such by socializing these practices and values. The following six aspects should be considered: (1) collaboration (as opposed to individual work); (2) laboratory tasks developed individually; (3) learning to act out within the social structure of the laboratory; (4) adaptation to a new way of learning; (5) learning a set of emotional responses; and (6) fit to the model of a 'good' science student.

Graduate students, as science novices, are also expected to collaborate with other research associates suppressing their eagerness to be acknowledged as competent researchers. Most of the time, they may be responsible for their own research projects within the field of expertise in which they enrolled. Therefore, it is also possible that their work is a part of a bigger research project which can make the graduate student feel that his/her work is invisible. Hine (2006) provides us with an interesting ethnography on how the development of a mouse genome mapping project, organized around a database, affected the social dynamic of the laboratory. It is of high importance to read how he describes graduates as being afraid, or rather reticent, to use the database as it was a collaborative tool to which every member of the lab team contributes with relevant pieces of information, and, in so doing, the members could use that information for their own research. In other words, he reported, based on the interviews that he conducted, how graduate students were afraid of sharing the database; they were deeply concerned about protecting their own data. In fact, those students delayed entering data to the database because they perceived it as a 'threat' to their individual work in terms of ownership. Furthermore, as we read in Hine's ethnography, some graduate students thought that any member of the laboratory could accidentally delete some of the data they were collecting for their individual projects. Or worse, that any member could use it for other purposes. Hine identifies this sort of situation as a "tension" between the role of the principal investigator – lab leader - and the graduate student. This could be due to the public face situation of the main investigator wanting to develop higher levels of collaboration, whereas graduate students always want to take hold of other projects to reach their personal goals as a step forward in their scientific or professional careers. In simpler terms, graduate students feel the need to be acknowledged for their distinctive contributions. It is obvious that this type of 'tension' brings about a certain kind of complexity in the role of graduate students because, on the one hand, they have to learn how to share or collaborate within the scientific goals of the laboratory, and, on the other hand, they feel that they have to make themselves 'visible' by claiming their own research goals to be accepted by the scientific community within his/her field of expertise.

A second aspect of graduate students' role as novices is to learn that the work carried out in a lab should be developed individually, as Benninghoff and Sormani (2008) claim. Undoubtedly, this rule might contradict the need of a GS to collaborate with the overall research that they support. This means that every GS should solve his/her research problems onhis/her own, although the research results have to be shared in a joint presentation in a scientific event (congress, seminar, or roundtable) or, consequently, in a 'paper'. Moreover, the GS has to learn the definition of a daily work routine summarized, after Benninghoff and Sormany (2008: 118) "you know, at this lab, it's everyone for himself" in his physics and genetics lab where he explored how academic identities were developed. He and his team also found that GS need to learn some "ordinary rules of conduct," as they call them. Like working individually, implying that often some students may "feel they were on their own." Perhaps, although it may pertain to a separate topic, the physical structure of a lab should contain one shared space for meetings and individual rooms for every member. It is common to see that people working in a lab rarely talk to each other; and at meetings, each GS is expected to present his/her findings, comments and observations of their research practices individually.

A third aspect is related to the novice role of a GS –obviously within the context of a lab ethnography –. The GS should deal with 'learning to act according to his/her position" in the 'lab social structure', that is, acknowledging the main researcher as the leader of the project and his 'impressive career trajectory' in the concerned field. Below him, are other colleagues working as collaborators, technicians, other GS and postdoctoral researchers. Each one should have an 'academic identity', as Sims (1999) describes it, in the 'division of labor'. He discovered this form of action in the testing of materials and structures governing an engineering laboratory where most of the research activities related to testing materials were done by GS, while faculty staff spent most of their time working at the same lab site or in research offices. Technicians and GS were described as working together although each GS was engaged in specific lines or aspects of the research project. Although within this social structure of the lab team there is a rank, every participant or co-worker should be included in the final results of the main research. Anyway, a GS is a 'key actor' in the mediation between the laboratory setting and the academic or scholarly work --a valuable factor for scientific development and the training of new generations of scientists.

Furthermore, based on Traweek's (1988) claims, the GS may assume the role of being 'acculturated' in a new way of learning –unlike undergraduate times—, a change from the formalistic ways of presenting science matters or contents posed by an instructor or, simply, as ateacher-centered process where memorization of facts and processes were rewarded with high or low grades. Now he/she has to learn how to move from undergraduate to 'graduate' ways of learning new scientific matters, how to develop reflexive thinking, hypothesis forming processes, and designs to conduct a research project together with testing hypothesis, and assess its results. It is a 'transition period' whose nature are the stages briefly stated in these lines by considering the GS as a 'high energy lab researcher'; here, all GS are asked to present an article and discuss it with other classmates. Throughout this 'transition period', Traweek (1988: 83) states that they develop a 'careful form of insubordination', meaning that the GS has to follow his/her advisor's instruction all the time although he/she is free to create for himself/herself in the framework of the advisor's counseling--the learning processes occur from peers in class, quite different from what they were used to. But this is not all, he also found that a GS will have to modify his/her 'emotions' when involved in research work. In a high-energy physics lab, they fear wasting time by conducting experiments not to be useful in their career advancement; many of them feel anxious about the future, shown by their search for acknowledgment and acceptance from the scientific community. But they also learn how to identify which projects are/were acceptable or poor. Being meticulous, patient and persistent are identified as 'pivotal characteristics when doing quality work in physics—also a good way to enjoy physics research.

Laboratories as learning environment

A lab setting can serve as a 'learning environment' since it is a place where GS can observe, practice and develop several skills that specifically will help them to become scientists--accepted by their 'community of experts'. Regarding the ethnographic approach, three main issues can be identified as valid not only for GS, but also for experienced scientists. Firstly, the power that lab artifacts have in the construction of scientific knowledge in terms of its historicity, monitoring experiment performance, and the organization of people and space. Secondly, how GS learn to convince other peers about the scholarly significance of the students' research work. Thirdly, in a lab, GS as well as scientists learn that the lab is located in a physical place as well as in a 'virtual' one.

With regards to 'artifacts', they are crucial for reducing and analyzing data to reach the final results. There are three ways by which artifacts become 'pivotal elements' when doing research work. They can inform lab members about the history of the scientific problem; they allow scientists to follow the trajectory of the experiment, and, they give the lab a physical and social organization. Nercessian (2006) goes deeper into this claim about the establishment of a relationship between history and cognition in a lab (mental processes that take place when knowledge is acquired). The ethnographic approach (hence EA), or simply lab 'ethnography' has rarely been used in the study of labs as learning environments. This approach is being known as 'cognitive-historical analysis', and its aimisto follow the trajectories of the interactions between lab members and lab artifacts in a type of a cognitive-cultural system. It means that in order to understand certain phenomenon, scientists need to design models to simulate that phenomenon. In so doing, they have to form a plan or to draw a sketch of, more than once, the artifact to fully understand the research problem and understand the process. Kurt-Milke, Nercessian&Newstetter (2004) ask themselves the following question: 'What has history to do with cognition? in an attempt to describe the nature of the interactive methods for studying research laboratories, specifically in the study of how a blood vessel works in real life, for example. It is clear that when producing 'simulations', the researcher and his team are able to extract a natural phenomenon from its natural context towards a controlled or artificial context; it is in this process or procedure where the history of the artifact design contributes greatly to improve research results. The conclusion that we can draw from Kurt-Milke's study is that when working in a lab, GS learn about the importance of being actively engaged in the process of the model design; it is in this way that they develop a sense of ownership of the artifact to better understand the research problem.

Laboratory artifacts can also help the team to identify and monitor or keep track of both the experiment trajectory and technical problems. In 2005 Mody (op.cit) did an ethnography on how 'wanted' and 'unwanted sounds' or noises produced by artifacts were indicators of a proper development in a given experiment, for example, microscopes were tested by clapping and stamping to see the acoustic isolation as a short or sharp sound of the clap shows up readily on the visual output of the instrument. By listening to the artifacts' sounds, the lab members were able to see the microscope's potential to solve particular problems during an experiment. Mody, in this way, could characterize the sounds as 'cool', 'mystical', 'neat', or 'ugly'. Therefore, now we know that artifacts also provide valuable data during the experimentation process. Another way of understanding lab artifacts lies in their ability to create 'social order' within the lab itself. So, by using an ethnographic approach we are able to bring about an organization of the lab space and its members; such is the case that Hine (2006) and Sims (2005) explored how the design and use of a database of the genetic mapping of a 'transgenetic mouse' affected the 'social order' in the lab, not only as a research instrument but also in shaping the dynamic of the laboratory. Thus, the database generated two 'epistemic groups' (from the Greek: 'episteme' = knowledge) or groups who share the same or related scientific training on one topic including technicians and scientists, each having a different or similar perception of the problem being investigated. For example, Sims (2005) studied the concept of 'traceability', or a visible mark or sign of a former presence/passage of another scholar, event or artifact, given at Los Alamos Pulsed-Power Lab were safety was the main concern. In order to make visible the invisible electrical changes of the pulsed power system to avoid danger, lab members needed to make them traceable. So, to trace the electrical changes the lab had to be physically organized. In so doing, there were established several behavioral norms governing the interactions between the machines and its operators. In this sense, these ethnographies show that lab artifacts bring about a necessary 'social order', an outstanding feature of scientific rigor and accuracy.

The laboratory environment, in the context of an ethnography, also serves as a learning environment for GS in terms of convincing other people about the importance of their research work and in terms of that they may contribute significantly to a specific field of a scientific domain. Fisher (2007), in an ethnography on a neuroendocrinology lab, looked at how scientists produced scientific papers. It is reported that one of the main tasks, within the lab, was to construct different types of 'statements' or 'claims' based on the results given in a certain experiment. These claims were the results of negotiations among members of the lab; in this way, the 'scientific fact' was reported not as something totally objective, but as an exercise in 'literary persuasion' (scientific journalism plays a very important role in it). By convincing colleagues or the related scientific community, and also the lay community interested in those matters, the researcher earns credibility, which allows him to be acknowledged as an expert in his fields or, at least, that as a GS he is just starting a scientific career. The consequences can be varied but interesting for the scientific development within a country: possibilities of applying for research grants, taking part in peer committees, and developing conversational skills to promote scientific circulation.

In relation to the question: how is the concept of life constructed in a lab? It must be said that it is a legitimate one since the GS has to learn to consider the lab setting as a learning environment. Thus, the manipulation of life – as we may call it for purposes of this article - in a lab requires 'deconstruction' in order to understand it in a better perspective in opposition to the original or natural way of understanding life as a fixed or steady process. For example, when working with animals, some novice GS have to deal with a sort of physical intervention into a living animal body.To carry out this task, they have to kill the animal just to analyze the physiology of their parts; in this process of life manipulation, GS learn concepts of life that depart from common sense realities. Lynch (1988:69), discusses how animals in a lab are gradually transformed from natural being into 'analytic objects' serving technical research; they learn how to convert animals, or living organisms, into simply 'data', that life is an object to be studied. Cohn (2004), in the same line, looks at how neuroscientists understand and conceptualize 'life' by using brain scan images. Even more, he backs up the idea that the concept of life, to some extent, has been disappearing from the official scientific discourse due to the fact that life in those scan images are represented by patterns of color representing, in this case, 'brain activity'. This suggests that the brain images cannot in fact show how the brain works; images are supposed to represent genuine or true life. The important point for a GS, from the point of view of lab ethnography, is that he/she learns about the complexity and ambiguity of a particular natural phenomenon. This ambiguity provides room for the construction of a discourse on how a phenomenon could work according to the needs or circumstances related to the social context of the research project. Thus, the concept of life and brain activity in a drug company lab might differ from the concept of life a scientist doing research on how human life evolved on earth. So, a GS in a particular lab will be able to develop and reproduce a certain concept of life according to his or her 'field of expertise'.

For a GS a lab cannot be only a room with four walls, but a boundless place; its existence depends upon variables translated into other physical and non-physical spaces. For the time being, as this article is part of a larger body of information consulted for my doctoral thesis, we can say that several studies have shown that a laboratory could be conceptualized as a place where the boundaries are not defined clearly and on an always steady framework; many actors and institutions affect what happens inside the physical room such as inter-lab collaborations or research teams in – among other things – writing or exchanging papers on-line, or simply by doing phases of experiments in another lab but the scientific dynamics is the same. Latour (1983),described a historical analysis of the process by which microbes were cultivated and domesticated by Pasteur to the extent that agricultural, sanitary and political institutions became interested in what Pasteur was doing. Although this is a long story – no space here for all – what we should keep in mind is that what occurs inside the lab influences what is going on outside and vice versa: it is what we may call 'private science' versus 'public science' (see Appendix at the end of this article). Furthermore, Fisher (2007), reported that when the members of the Thermal and Nanotechnology Lab had to make decisions on how to perform an experiment, they needed not only to consider the internal aspects of the lab (equipment and types of measurement) but also external factors such as environmental, health issues on contamination and disposal; how different actors and institutions interact with the lab can be understood as a 'trading zone'. Also Sims (1998), in his fieldwork on an earthquake engineering lab, observed that in reality the lab was part of a chain of four arenas: construction, academia, design, and the lab itself. Among them, it was possible to distinguish trading zones where technicians, test specimens, graduate students, computer models, faculty, texts, and modeling methods, etc., interacted. Their interactions were able to produce wise alignment of the research results with the corresponding benefits for the institutions concerned.

The ethnographic frame as learning environment

When laboratories, as learning environments, are studied using an ethnographic approach, it is possible to identify three particular insights in which a scientific culture can be located. Anderson-Levitt (2006), also studied the social interactions in a lab between the lab head and the artifacts used to construct scientific knowledge on the basis that ethnography is conceived as an approach to understand what people do, believe, and think in the ongoing activities of everyday life. As such, ethnographies have been useful in studies of other human groups like speech, classrooms, and communicative practices in human groups; ethnographies capture meaning production within groups of people. Therefore, the mind, social interaction, and artifacts are often culture-related; in this perspective life in a scientific lab constitutes a learning environment (hence LE). First, an ethnography illuminates what happens in the inner atmosphere of a scientific research as to how to solve problems, the type of language used for exchanging information (whether science formality or everyday discourse). But the most important fact is how scientists, associate researchers and graduate students (GS) generate learning.

Which are the challenges or possible problems that could arise when using an EA or EF? These can be summarized as follows: (1) the degree of the ethnographer's participation or engagement in the field; (2) learning science contents and processes when the ethnographer is an outsider; (3) the ability to focus on one aspect of the activity provided by the lab; (4) the multi-sited nature of the labs' fieldwork; and (5) providing a consistent account of what goes on in a lab.

When the ethnography is used to study a lab as a 'learning setting', it is possible to grasp what is happening in the lab member's mind in a problem solving situation as this can be witnessed in its context. Kurz-Milke (2004) commented that when a GS is trying to solve a problem in designing a model of blood vessel, an ethnographer is able to understand that situation by asking the student what he or she is trying to do. He can also have access to understanding the materials used in the machines' functions at the moment of designing a blood vessel model. Although the GS can provide a detailed account of how to solve the problem, the ethnographer would not actually be able to observe the work in progress. Now, when doing the interview, the knowledge that the researcher receives might be partial as there is no access to the artifacts and the current situation or simply the 'context'. Consequently, the EF (ethnographic frame) provides a detailed account of what happens when a GS is being trained in the scientific processes occurring at the lab.

A second insight or deep view that an EF can provide – when looking at labs as LS – is based on the information provided when observing the social interactions among lab members that an ethnography can detect and describe. It is really a special dynamics shown in lab meetings when high-energy physicist discuss how to address a problem in an experiment; GS learn from listening to their peers' discussion; they also learn when they suggest ideas or ask questions in the lab meeting. The ethnographer him/herself might be able to ask questions during or after the meeting just to figure out what was going on, a fact that would not happen by using direct observation, situation which is similar in a video analysis. It is clear that by using an EF it is possible to get a more holistic description of how people learn in a lab through experiencing the different activities in the learning interactions. And above all, we have a complete picture of 'science learning' taking place in a lab, how the scientific knowledge is constructed, its history, its progress, experiment monitoring, and people-space organization.

Generally speaking, understanding and experiencing the functions of the lab tools as developed in this article up to here, would be more difficult if we resort to simply direct observations or interviews. The former might not show the dynamics or forces coming up throughout the interactions between lab artifacts and the scientist or team. As an anthropologist may claim, an interview only captures the concepts and meaningful distinctions for participants in the case of working with GS – the 'emic' perspective' - which transcends the mere act of observing – the 'etic' perspective. Anyway, both viewpoints are valid and important when taking ethnographies to the lab settings by taking into account that he/she – the ethnographer – might not have a high degree of participation which could be a limitation to provide a complete portrayal of the lab situations as his role could be regarded as an interference; by all means the aim of any ethnographic work does not have a purpose of this sort. Just to avoid wrong judgments, his/her role should not go beyond one month or a couple of weeks, time enough to develop appropriate rapport to capture meaning of what 'goes on in a lab', nothing else. Perhaps it is recommendable to be a little bit acquainted with the scientific contents being dealt with at the time of developing the ethnography.

Although it may seem unthinkable, the issue of being able to be virtually and physically in more than one place poses another important challenge in doing lab ethnography. As far as this is concerned, Beaulieu (2007: 9), suggested that it is rather difficult nowadays that any kind of 'fieldwork' be only physical, that is, having an area of a place where to conduct an ethnography. Science Laboratories are no more only physical buildings bounded by walls. Currently, collaboration and cooperation among research groups take place or are located in the 'cyberspace' or the electronic media of computer networks in which on- line communication occur. This means that an experiment might be completely developed in one laboratory but rather in multiple ones due to the availability of devices and experts for each experimental stage. In this context, an ethnographer should also be able to deal with multiple sources of information, more labs, web sites, blogs, chats, e-mails, text messages, video chats, etc. Beauliey calls it the "ability to switch from one type of presence to another." Hine, likewise, (2007), states that the construction of knowledge in lab settings, as well as its implications, takes place in social, educational and political institutions through communications between scientists in a global world , and no longer exclusively within the walls of a lab.

Finally, providing a detailed and coherent account of what happens in a lab is or will always be a challenge that ethnographers face, especially when communicating the findings. This issue is related to how he or she represents a group of scientists (hard or soft) to be studied, as viewed from the ethnographic perspective he/she is both the 'researcher' and the 'research instrument', therefore the descriptions that are accounted for must be reliable and coherent in the sense that the results should point to the 'meaningfulness of the lab activities' as well as convincing that he/she was there as Geertz (1988) sustains it.

Conclusions

Throughout these pages we have reviewed how an EA may be useful in the study of the dynamics of a scientific lab as a learning environment. Obviously, there are interesting interactions among researchers and graduate students as prospective researchers with lab 'artifacts' or objects produced or shaped by human workmanship (from Latin: 'ars= create; 'factum= fact or something made) with a specific projection towards a new knowledge. We also reviewed the role of GS in a laboratory life in their learning experience within an ethnographic frame or EF. The evidences used here were taken from different specialized sources as; neuroendocrinology, earthquake sciences, physics and model design for the study of blood vessels, among others.

What practical implications do EAs have to understand the scientific work? Although the answer leaves room for another paper, we can ascertain that the step from ethnoscience to science is just beginning. Anyway, facts like labs as learning environment, the notion of an ethnographic frame together with the roles prospective scientists (graduate students) will lead the coming discussions relevant to specific disciplines or branches of sciences through further or deeper implications for the development of science curricula in an educational system at the time that these discussions will open spaces for thinking of better teaching methodologies for the improvement of science, that is, the development of a new 'epistemic culture' or 'reasons for learning science 'as I will call it from now on.

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