Professional and Practice-based Learning

Monica Kennedy
Stephen Billett
Silvia Gherardi
Laurie Grealish *Editors*

Practice-based Learning in Higher Education

Jostling Cultures

Springer

Monica Kennedy • Stephen Billett
Silvia Gherardi • Laurie Grealish
Editors

Practice-based Learning in Higher Education

Jostling Cultures

Editors
Monica Kennedy
University of Canberra
Bruce
ACT
Australia

Stephen Billett
Griffith University
Nathan
Queensland
Australia

Silvia Gherardi
University of Trento
Trento
Italy

Laurie Grealish
Griffith University
Gold Coast
Queensland
Australia

ISSN 2210-5549 ISSN 2210-5557 (electronic)
Professional and Practice-based Learning
ISBN 978-94-017-9501-2 ISBN 978-94-017-9502-9 (eBook)
DOI 10.1007/978-94-017-9502-9

Library of Congress Control Number: 2015932079

Springer Dordrecht Heidelberg New York London

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Contents

Contributors

Stephen Billett Griffith University, Nathan, QLD, Australia

Matthew Campbell Griffith University, Brisbane, QLD, Australia

Marcelo de Souza Bispo Federal University of Paraíba–Brazil, João Pessoa, Paraíba, Brazil

Silvia Gherardi University of Trento, Trento, Italy

Laurie Grealish Griffith University, Gold Coast, QLD, Australia

Gold Coast, Australia

Catherine Hungerford University of Canberra, Canberra, Australia

Patricia Kench University of Canberra, Canberra, Australia

Monica Kennedy University of Canberra, Bruce, ACT, Australia

University of Canberra, Canberra, Australia

Ceri Macleod Flinders University, Adelaide, South Australia

Natasha Shaw Queensland University of Technology, Brisbane, Australia

Heather Smigiel Flinders University, Adelaide, South Australia

Judith Smith Queensland University of Technology, Brisbane, Australia

Helen Stephenson Flinders University, Adelaide, South Australia

Jennifer Tredinnick Queensland University of Technology, Brisbane, Australia

Assunta Viteritti Department of Social and Economic Sciences, University "Sapienza", Rome, Italy

Jackie Walkington University of Canberra, Bruce, ACT, Australia

Jordan Williams University of Canberra, Bruce, ACT, Australia

Karsten E. Zegwaard University of Waikato, Hamilton, New Zealand

Chapter 9
Practice-Based Learning of Novices in Higher Education: Legitimate Peripheral Participation (LPP) Revisited

Assunta Viteritti

Abstract The chapter extends Lave and Wenger's Legitimate Peripheral Participation concept to Higher Education and intends to review the concept of LPP by placing the role of novices and technical materiality at the heart of practice-based learning. A narrated description of the events observed in the lab shall attempt to show how a novice learns through practice and with others (both human and non-human), emphasizing the idea that in Higher Education too, and particularly in the passage from the lecture hall to the laboratory practice-based learning is situated, socio-material and participated. The pedagogy of practice, activated in the scientific laboratory context fosters the co-existence of learning practices and academic interests, producing tension between codified knowledge and unstable expertise in evolution, between the procedural standards and artisan skills incorporated by both novices and experts. Only by integrating these two types of knowledge can a robust university training and qualification be achieved.

Keywords Learning · Novices · Scientific practice · Sociomateriality · Higher education · Practice-based learning · Legitimate peripheral partecipation · Human · Non-human

Theoretical Premises

This contribution, which merges the situated learning perspective of Lave and Wenger (1991) with that of the studies on materiality according to the Actor Network Theory and Science and Technology Studies (Latour and Woolgar 1979;

A different version of this paper it was published in the 2012 (Viteritti A. "*Sociomaterial Assemblages in learning scientific practice: Margherita's first PCR*" in TECNOSCIENZA: Italian Journal of Science & Technology Studies http://www.tecnoscienza.net/index.php/tsj/article/view/91). Now, in this new version I would to explore some different elements that permit a re-conceptualization of learning and in particular the role of LPP in Higher Education.

A. Viteritti (✉)
Department of Social and Economic Sciences, University "Sapienza",
Salaria Street 113, 00198, Rome, Italy
e-mail: assunta.viteritti@uniroma1.it

M. Kennedy et al. (eds.), *Practice-based Learning in Higher Education,*
Professional and Practice-based Learning 10, DOI 10.1007/978-94-017-9502-9_9

Lynch 1985; Knorr-Cetina 1999; Latour 1987), intends to review the concept of *Legitimate Peripheral Participation (LPP)* by placing the role of novices and technical materiality at the heart of practice-based learning. The contribution has two aims: to extend Lave and Wenger's (1991) PPL concept to Higher Education, viewed as a field of theoretical/practical apprenticeship, and to propose a review of the concept of periphery attributed by Lave and Wenger to novices in order to demonstrate the central role played by the newcomers, who become involved in a process of accelerated practice-based learning thanks to the collaboration of technological artifacts in the laboratory. The relevant cultural source of the paper is that of practice-based studies of learning and knowing in organizations (Gherardi 2000; Nicolini et al. 2003), which have contributed to changing our vision of knowledge from a stable, mental, de-conceptualized, individual, codified conception to one which is situating, social, negotiating, practiced, emerging and incorporating in the body of subjects and in the artifacts.

The chapter starts with the assumption that the process of participation in which a novice becomes involved is neither linear nor progressive: it is not a trajectory which leads the novice from the margins to the heart of practice gradually and through time. The hypothesis underpinning this work is that this process is dynamic ad articulated, and sees the newcomer manage uncertainties, artifacts and relationships towards which he or she must demonstrate responsibility and dexterity from the outset. In this accelerated process of acquiring mastery, the intermediating role played by the technical artifacts which contribute towards speeding up and problematizing the trajectory leading the novice to the core of practice, becomes ever more relevant. Situated learning is based on the assumption that knowing and doing are inextricably intertwined (Gherardi 2011): learning is a process for the incorporation and continuous translation of knowledge into practical actions, an active participation process in which the learning subjects are involved as key players. In this perspective the learning investigated through observing the novice are sociomaterial actions (Orlikowski 2007) situated within a network of activities involving people and objects which together produce knowledge, that practical knowledge which materializes in both the experts' and the novices' hands through highly standardized procedures and techniques. This paper, therefore, intends to affirm that learning is social and practical (Fenwick and Edwards 2010; Sørensen 2009) in the field of Higher Education, too, and is characterized by the intertwining of heterogeneous human and material aspects. The idea is to examine the experience of learning scientific practice in the transition *between* the learning of academic knowledge in lecture halls, where knowledge is codified and stable, and the appropriation of knowledge by doing, *in action*, in the laboratory, where knowledge is still hybrid, vulnerable and malleable, as it is developed in the relationship between humans and non-humans, between the materiality of technical devices and the sociality/corporeality of experience.

The outcomes which Lave and Wenger report in their research regarded contexts of traditional practice, but what happens when the contexts under analysis are learning and working environments steeped in technology? Can the learning contexts contribute to reviewing the concept of LPP? Do *technologically dense*

environments (Bruni 2013) accelerate the processes which position the newcomers at centre-stage? The concept of LPP in social anthropology is a crucial part of situated-learning which implies involvement in practical activities carried out in specific contexts. Research into situated learning studies how people acquire knowledge and competence in social processes outside formal training contexts, too. In the consolidated vision of LPP, the novice interacts with other members, moving from the margins towards the centre of practice, and in this trajectory acquires practical culture in context, thus becoming expert. This paper intends to review the concept of *periphery*, hypothesizing that the mediation of technology and materiality produces an acceleration of the trajectory of participation. In the studies by Lave and Wenger, technology, though mentioned as being relevant, is not fully appreciated as an element in the participation. It is taken into consideration, though not fully analyzed for its relevance, but rather set aside and treated as a mere tool. Another element is that these studies were based on somewhat more traditional manual and artisanal professions, such as midwifes, tailors, butchers and helmsmen, as well as members of Alcoholics Anonymous. The learning trajectory is framed by a progressive, gradual acquisition of the trade and of the contextual professional culture, developing an awareness through time. Today, the contexts of practice are characterized by processes of greater instability and mobility, in which technical artifacts often serve as accelerators in participation. Thanks to these, the novices are interconnected into articulated systems of practice in technologically dense environments, which foster a more rapid participation. In this type of context, knowledge, which is never individual, allies itself and connects with heterogeneous elements of practice.

A narrated description of the events observed shall attempt to show how a novice learns through practice and with others (both human and non-human), emphasizing the idea that in Higher Education too, and particularly in the passage from the lecture hall to the laboratory, practice-based learning is situated, socio-material and participated.

Field and Research Methods

The chapter tells the story of Margherita, (Viteritti 2012) a university student, who is preparing her thesis, and who, in her first few days in the laboratory, encounters the PCR[1], a technique in molecular biology. A scientific research laboratory is part of a university context, and commonly held to be an environment which privileges theoretical, disciplinary, abstract, de-contextualized, codified knowledge. It is a place where standardized knowledge is transmitted and transferred by the more expert (the professors) to the less expert (the students). University life has often been

[1] The *Polymerase Chain Reaction*, commonly conveyed by the acronym PCR, is a molecular biology technique which allows fragments of nucleic acids from DNA to be amplified. Amplifying using PCR allows scientists to obtain the quantity of genetic material necessary for successive applications and experiments very rapidly *in vitro*. The technique was invented in 1983 by Kary B. Mulis, who won the Nobel Prize for Chemistry for this in 1993.

considered to be an extension of school life, merely differently organized. In the context of university teaching, what counts are the disciplines and their traditions, the controversies regarding theories and the debates surrounding those disciplines. In every field of university knowledge, from Physics to Social Sciences, codified, specialized knowledge is placed on a pedestal from a theoretical, methodological, historical, and perhaps even a practical viewpoint. However, in the in the last few decades, practical learning processes have begun to count even in university lecture halls, teaching curricula and evaluation tests, and the predominance of mere knowledge has given way to valuing competency and "knowing how to do something with your knowledge", too. The university sphere has become a context in which practical knowledge is experimented in laboratories, experimental teaching, internships and apprenticeships. This contribution aims to investigate the second phase in the history of academic knowledge, that in which theoretical knowledge catches up with and transforms itself into practical know-how. When for a student, (a biology student in this case), after having sat and passed a certain number of theoretical exams, read volumes and articles, taken notes for semester after semester and carried out practice exercises in teaching labs, the moment for practical training arrives.

At a certain point in his or her career, the transition from the biology lecture hall to the scientific laboratory takes place, and this happens when the student has to face the final tasks which lead to graduation. In that moment the student moves on from books to test tubes, from note-taking to molecules, from codified knowledge on the whiteboard to the more unstable variety evolving in the hands of experts in the laboratory and from mere words to cells. Along with the nature of learning, objects of reference, actions, procedures and practices all change. The student moves on from the obligations of teaching to the responsibilities of learning. The scientific laboratory thus becomes an extension of the university environment, a place where learning processes develop through practice in a context where significant social and material interactions develop and where the situated know-how typical of apprenticeship is generated. Scientific research laboratories become spaces for translating and converting knowledge. They host university students on internships geared to their theses, Phd students, etc. They are places for academic apprenticeship in which the disciplinary knowledge acquired in lecture halls is disarticulated and recomposed as practical know-how. In research laboratory practice, codified, stable academic disciplinary knowledge (Physics, Biology, Chemistry, etc.) is dismantled, reorganized and retrieved in other form, then translated into practical know-how to be learnt materially and manually through the senses (Goodwin 1994). In the laboratory, scientific knowledge is transformed into practical action requiring the heterogeneous enlistment of both people and objects. A student's participation in laboratory activities is very different from what is required of him or her in a university lecture hall: there words and listening are what count, here it's observation and active social and material participation.

The laboratory is a special educational area which favours a curriculum activated and experimented through practice (Fenwick and Edwards, 2012) and places the relational effects between sociomaterial events and researchers centre-stage, unlike scholastic and university contexts which privilege a formal, codified one. Scientific

laboratories are interstitial spaces between academic and business organisations, basic and applied research, experience-based knowledge and codified knowledge. Scientific research laboratories are *boundary places* (Star and Griesemer 1989) where formal and explicit learning, informal socialisation, tacit knowledge (Polanyi 1966; Collins 2010) and expert practice intertwine, and educational places where knowledge is always a shared practice, being the product of human and non-human assemblages. Like other professional settings, laboratories are spaces embodying a pedagogy of practice (Kaiser 2005). The processes in which researchers face problems, search for solutions, learn and embody roles, draw on established knowledge, create new knowledge and make themselves familiar with daily practices constitute a daily pedagogy, which is not abstract or pre-established: it is not inside people's heads or in manuals, but is embedded in the process of knowledge appropriation.

Through a detailed account, the paper shows how the novice, albeit under the supervision of a senior researcher, immediately takes centre-stage in the practice, thus supporting the texture (Gherardi 2006) of the practices performed by more expert researchers. The hypothesis is that in research laboratories (as well as in other workplaces) newcomers are immediately involved in the construction and organization of the established routines that constitute the crucial and ordinary activities in the context. The idea is that novices do not just stand and watch the world from the margins, gradually getting the hang of things through increased involvement, but are immediately cast into the practice in order to support and contribute to the work of the community. The novices are quickly called upon to enter into the heart of laboratory practice and soon become productive resources. They are *catapulted* into action and immediately realize that their daily practice is at the basis of all laboratory activity.

Novices, and in particular those like Margherita who join the laboratory in order to complete experimental theses for their degrees, experience an initial phase of disorientation or *breakdown*. Entering the laboratory is like crossing a cultural threshold, in the sense of the knowledge acquired in the transition between two educational spheres: that of the university lecture hall and that of laboratory practice. The young apprentice scientists discover that scientific knowledge, which till that moment they had learnt mainly from textbooks and university teaching of the transmitted variety, is rather a practical, material, social and relational process. During their first period in the laboratory they strive to distance themselves from a vision which perceived knowledge as being a codified, certain result to one where knowledge is seen as a process, a situated, local action, a relational effect which links people and objects (Latour 2005). Collaborating with a senior (and also working with other colleagues) leads the novice to an *all-practical knowledge vision*, far removed from the codified university variety.

In the work field, I assumed an ethnographic perspective (Atkinson et al. 2001) which required a lengthy period of observation. For several days, using the *shadowing* technique (Czarniawska 2007), I therefore began to follow Margherita. In this story, we observe Margherita as she becomes familiar with her work environment and grows from being an insecure, inexperienced novice to an independent, reflexive and skilled young researcher.

The University Laboratory as a Learning Space for Novices: Margherita at the Center of Scientific Practice

Margherita's first days in the laboratory took place in silence. She's not a *tabula rasa*, she has already been in another laboratory in the course of her university studies, where she learned how to manage diverse instruments and carried out all the tests used in molecular biology.

She has therefore already acquired a certain dexterity which gives her a sense of security and practical ability in daily laboratory life. Margherita has already incorporated a measure of practical know-how and behaves in a "natural" way: her previous experience in an academic context on earlier occasions (experimental teaching, practice, teaching laboratories, visits to other Biology labs, the accounts of other colleagues, etc.) have given her the opportunity of "accumulating" a certain degree of experience in the form of tacit knowledge, which she can draw on and now exhibit, translate and adopt.

She, therefore, has some knowledge of the environment, and knows how to avoid getting in anyone's way, how to move agilely between workbenches and computers. These early phases of her practice are similar to the tailors' learning practices described by Lave and Wenger (1991), with a short period of time defined as "way-in" during which Margherita observes, tries to make herself familiar with her workspace, with the objects and people around her. In her first days in the laboratory, she is flanked by another young intern, a girl who has already spent several weeks there, and it is with her that Margherita begins *to find her feet*, learns where the instruments she will have to use are kept, familiarizes herself with the *material geography* of the laboratory, learns about those who surround her together with someone who has already elaborated a map of this reality and can share it with her. As also Lave and Wenger affirm, the apprentice often learns from the relationships he or she establishes with other novices and from the circulation of information which tends to constitute the conditions for learning itself.

At first, Margherita focuses on elementary but highly important matters: cleaning the workbench, discovering where the most commonly-used objects, such as the containers where events and materials crucial to the laboratory—the cells, the primers, the test-tubes, etc.—are kept. She discovers the scientific articles scattered around, the students' pipettes, begins to recognize the everyday gestures, experiments the first stages of acting, or rather, acting in its first stages. At random in a notebook, she writes down details of the information she begins to select: what some object is called, a telephone number, the names of suppliers, some notes on *primers*, the access code to the computer, small but vital details to hang onto in these first days in which she feels like she's holding her breath. The space is densely populated with heterogeneous objects, which serve theoretical and practical functions and will gradually be embodied and domesticated by Margherita. Pipettes, hood, fridge, computer and microscope will be the instruments she has to gradually become familiar with. Primers, cells, DNA and laboratory animals will be other partners she will have to deal with, and ally herself with, in order to achieve the

expected results. On top of that, there are also colleagues, peers and seniors with whom Margherita will share her process of socialisation and become familiar with the practice that is going to transform her from a novice into an expert.

Her activity must find its place in a network of actions and the human and non-human actors that make up the context. This is not a given thing: it is not a closed container in which she must find her space, but rather an articulated system of relationships, a fabric (Goodwin 1994) that she must contribute to building and weaving.

One morning I observe that Margherita, watched over by Marta, the senior colleague she will be working with, will carry out her first PCR methodology for an important project in the laboratory. She has been assigned a task: the project she is involved in is not simulated, but an authentic research project involving the study of DNA in a neurodegenerative illness. Margherita is introduced to the practice and is given the key elements to legitimately approach the tasks she has to learn. I therefore decide to follow Margherita's first steps in action. She studied the PCR technique for her molecular biology exam and has seen it done by others: now it's her turn. Let's follow Marta and Margherita as they approach the practice that the newcomer will have to learn. With a quick hand-drawn diagram, Marta shows Margherita how the process they are about to start up will develop.

While Marta and Margherita set things up for the PCR, all the others in the laboratory are otherwise occupied: at their workbenches, computers, using measurement technologies, quantifying, at the centrifuges, at one of the PCR machines, in the cell room, bent over a workbench, waiting for the use of a machine, standing at work in the chemical hood or seated and reading with concentration: everyone's material time is programmed. The networks of practice all around her sustain her in the task she is beginning to carry out: they provide a world of reference that supports and comforts her.

Margherita dons her white coat and gloves and, following Marta's instructions, goes to the fridge to get ice for the biological samples. "*First of all, clean the workbench and wash your hands, you have to get ready to manage the situation well*" says Marta, and Margherita gets methylated spirit and begins to clean the workbench precisely and thoroughly. Still following Marta's instructions, she also cleans the pipettes she will be using. Workbench ready, Marta says "*let's go to the computer to draw up a plan for carrying out the various phases of the experiment, an action map we can follow*". Having prepared the plan, they return to the workbench and Marta begins to explain what Margherita is about to do. Margherita takes down quick details in her notebook. Now Marta is explaining the steps, the dilutions to be made. Margherita prepares the pipette carefully, and Marta shows her how to use it. Margherita prepares the test-tubes, makes a note of the dilutions they contain but continually asks for confirmation from Marta. Margherita has to be very careful not to touch the rims of the test-tubes with the tip, as if she manages to do so, Marta tells her, she can continue to use the same tip, otherwise she has to throw the tip away and get another. Margherita notices that she has touched the rim of the pipette with the tip and says, "*No, I've wasted one, I touched it!* " She is able to feel that she touched the rim of the pipette with the tip, so her sensitivity has already developed.

She has enhanced her situated perception skills. Now there is an exchange of perceptions and sensitivity between them, they don't talk much: each of them, to a greater or lesser degree, knows what she has to do. This link with the elements of the practice accelerates their perception and sensitive competency (Viteritti 2013).

Margherita makes a note of what she has done until now in her notebook, she can't be expected to remember it, every gesture must be recorded in her notes: that night she will go through them, certain now of what she must "do", but it's important to memorize the process, the direction, the chain of events in their order. Margherita arranges the test-tubes and puts them back on ice. "*Now we'll prepare the dilutions checking the measurements with the plan we prepared beforehand on the computer*". Margherita needs to concentrate on the movements of her hands and the focus of her attention. Slowly, at first uncertain and then more and more sure of herself, encouraged by Marta, she proceeds. "*Now we'll move on to loading the samples into the multiwell*", says Marta as she shows her how to pick up the Petri dish and warns her of the constant risk of contamination: "*the Petri dish mustn't be held between thumb and middle finger leaving the index finger suspended, but should be held using thumb and index finger, look, like this, never move your hands directly over the dish, organize your workspace well*".

They load the multiwell onto the PCR machine and from then it will take 2.5 h to achieve results. After the loading, Margherita can relax and takes a deep breath, as if she had been holding it until then. She says, "*You're there, a bundle of nerves and concentration, listen to me, I'm hoarse, I'm done in, but it's great*". While waiting for the results, they place the primers back in the box and put the box in the fridge. The waiting time since the multiwell was uploaded onto the PCR machine has elapsed, so they now look at the results. During the experiment Margherita has tested her perception of the social and material space, the sensitivity of her hands, of her eyes, of her touch; she has started perceiving, hearing, seeing, trying to understand. In her dialogue with Marta, she has been engaged in expert communication and introduced to the most relevant area of laboratory practice. She is a novice, but her participation is not peripheral: right from the beginning, she has got to the heart of an experiment that, while it is a routine procedure, is also fundamental for the project they are working on. She has started establishing relationships and becoming familiar with technological and bio-technological artifacts, such as pipettes, *primers*, centrifuge, computer, PCR machine, DNA, measuring instruments, etc. In critical moments, Margherita has learned by making mistakes; her gestures are not repetitive and taken for granted yet, but her body is receptive. Margherita has plunged into the laboratory world, perceiving it, moving her body in a temporalised space, getting to the heart of a process of embodiment of objects and functions (Yakhlef 2010). Her body starts being disciplined without her being fully aware of it. She is still quite tense, but she already feels the corporeal density of the practice she is becoming familiar with. Margherita's access to the practice was not marked by explicit moments of theoretical teaching. What is important, for Marta (as well as for Margherita), is learning a specific task while carrying it out. This shift from teaching to learning in practice was also pointed out by Lave and Wenger (1991). Through her efforts, here exemplified by the episode of the PCR test, Margherita

establishes a meaningful and passionate relationship with the materiality of practice: there is no knowledge beyond its practical application. Even developing dexterity in handling tips or creating new concepts is a practical exercise, a learning *effort* that also involves objects (Gibson 1986). Scientific knowledge, as shown in the above-mentioned episode, does not lie somewhere in people's heads or in metaphysical laws, but is socially constructed through the accumulation and fine-tuning of skills developed, embodied and sharpened to solve everyday problems: the struggle for knowledge is conducted through the appropriation and sharing of problem-solving skills and training.

In the space of a few weeks, Margherita has mastered the practice. She has inserted it in a more ample context of things she has learnt, with regard to which she is now completely autonomous. Now the PCR tests are in the order of hundreds, while at the beginning she did three or four a day. She has become swift and expert. She has learned to move across a plurality of practices and has also acquired competence in cell biology. She is able to distinguish different cell lines and develop her own work plan, and her results contribute to the others' tests. When Margherita enters the laboratory, it is already an established environment, and she ventures into this contest with her hands, her glance, her thoughts: she slowly becomes familiar with the malleable objects (both technical and biological) in circulation there. Thus her autonomy, her competence of movement and her ability in interpreting the events increase, and as Margherita familiarizes herself with the material context, her attachment to events grows (Hennion 2004). Margherita has now mastered not only "how things are done" but her actions have also acquired a rhythm, a fluidity which is apparent in her explicit use of language. Autonomy manifests itself in a stronger link with all the human and material events.

Some Conclusions

> *The knowledge, the subjects and the objects of knowledge may be understood as being produced together within a situated practice* (Gherardi 2001, p. 2).

This is what emerges from my observation of Margherita's entry into the laboratory and her practical training. From this little story, we can see how knowledge takes shape and how it resides within social relations mediated by technical objects.. In order to master the practice, which is neither linear nor progressive but rather intermittent and circular, Margherita learns by imitating and is inspired by random, situated stimuli which emerge from daily practice. Her daily practice is closely linked to the practice of others, her colleagues in the laboratory who represent a relevant imitative source (in the open-space workplace, at the workbench, under the chemical hood, in meetings where results are discussed). Margherita follows an individual trajectory of her own, but this is built through *effectual reciprocity* with other heterogeneous elements which she encounters in practice. Margherita has domesticated herself, established a relationship with objects and learned to develop independence and awareness. The docility, efforts and difficulty of the process of

appropriation are a result of the intertwining of heterogeneous elements, as well as of self-discipline (Kaiser 2005), which is the individual's contribution to the learning process. Margherita's training is represented by a chain of sociomaterial processes rich in human and non-human elements.

The episodes related to Margherita's learning process show that there is no precise and pre-established order of events, no explicit set of knowledge to be taught: knowledge is rather situated in the practice and emerges from a process of appropriation of *knowing in practice* (Gherardi et al. 2007), this depends on the knowledge experienced and developed in specific situations. The process of *knowing in practice* is *distributed* across objects and tools (Hutchins 1995), embedded in technologies, rules and procedures. In Margherita's growing number of relationships and connections with the heterogeneous elements in the field (the management of the workbench, the progressive dexterity in handling pipettes, the relationship with the cells under the hood, the knowledge of instruments, the domestication of their use, the adaptation of her senses to the use required by the objects in the field, etc.), in her increasing appropriation of the environment and internalisation of the context, she establishes a stronger inter-individual and inter-objectual connection with the elements in the field. The little story of Margherita shows that it is much more productive, from an analytical point of view, to develop a *post-humanistic approach to learning*, because: through this theoretical sensitivity, objects, technologies and space are no longer 'matters of fact' (objects in a static sense), rather they become 'matters of concern' in educational practices, for practitioners as well as for researchers (Landri and Viteritti 2010). Margherita is interconnected with the world of *objectual practices* (Knorr Cetina 1997, 2001) and the material objects become part of her field of relationships. The materiality of the laboratory world, which makes it possible and accompanies the daily process of knowing, is not cold and distant, but becomes familiar, absorbing and close (Gibson 1996; Gherardi et al. 2007).

This story has tried to express the sociomaterial relevance of the practical learning produced in her debut in the laboratory, in the relationship between the biotechnological *objects* and the *sensible knowledge* (Strati 2007) of the researchers, the appropriate expertise which is expressed through the sensitivity of the learner and is linked to the practical context.

As we have seen in the case of Margherita, in the laboratory, it is often the young who are in charge of the routine daily events (from managing all the experiments to caring for the technologies to caring for the cells on a day-to-day basis) and who monitor the greater and lesser uncertainties (checking the infrastructures, managing minor accidents, etc.). Their seniors intervene to correct the course of events, to monitor the results, to programme future steps, but it is the young who govern the everyday laboratory life and who elaborate the fields of practice. Day by day, the novices handle the link with the materiality of practice: they support it experimentally and stabilize it through the care and precision they put into their daily actions. They are the true regulators of daily events: in fact, they manage crucial routines, look after the cells, keep the workspaces tidy, keep up with the details of experimental work practices, do and re-do everyday tasks with the same care and meticulous

attention. Without them, scientific work would lose both density and intensity. Their contribution is therefore in no way peripheral: they are at the very "heart" of daily practice. Of course, in order to gain full recognition, their practice must be firmly anchored to the work of their more expert colleagues, whose developments in scientific work are *founded* totally on the experimental practices the novices accomplish day by day. Probably the most important thing to emerge is that often when observing the practice of laboratory work—and not only in this environment, but also in a wide range of workplace contexts—I have noted how it is the work of the beginners which sustains the knowledge of the competent, and allows it to develop.

The aim of this chapter was to suggest that situated learning among novices in the laboratory supports the experts' practices. This occurs through forms of participation which soon become central as the novices immediately enter into the entirety of the sociomaterial networks of relationships linking people, activities, materials and the world which constitutes community practices (Gherardi 2009). Learning thus amounts to a *social* practice which demonstrates the interdependence between the actor and the world surrounding him. In this sense, the *peripheral* status of the novices does not contrast with the experts' *full participation* (unlike what Lave and Wenger affirmed in their work). The newcomers immediately participate fully and this is expressed through the continuous situated negotiation of the interaction's meanings. All these activities favor the dissolution of the dichotomies separating mental and concrete activities, abstraction and practical experience.

Apprenticeship in practice is ever more crucial in contemporary society, also due to the fact that it is motivated by the high degree of professional specialization required and the emerging role of technology. Sometimes the young people themselves (already socialized to technology and technical artifacts) gain immediate access to technical means and it is not only formal learning that can guarantee the only opportunity of acquiring the skills for negotiating them. Practical experience draws up a *situated curriculum of learning* for apprentices: it constitutes a situated opportunity for the development of practical abilities and taking part in a community means learning its languages and material culture.

From the little tale of Margherita, we can see how university experience—articulated between lecture hall, practice, internship and laboratory—can constitute an early socialization to practice. In any case, laboratory practice is a continuation of formal university training in another form. This is not because work practices in themselves are capable of controlling and guiding formal educational practices, but because formal education without complementary practice is as if mute and lacking in ductility. By extending the concept of LPP to university training, we can explore and expand the concept of participation, which includes formal learning environments as well as practical learning contexts. The concept of periphery, too, is debated and enriched. Where is periphery situated in an academic context? University learning occupies an extensive area of legitimacy, ranging from the lecture hall, to the place of experimentation of codified disciplinary knowledge, to training experience acquired through laboratory work. One becomes expert in the translation of codified disciplinary knowledge, which becomes sensitive experience in experimental practice in the laboratory: the learning process is completed through practice

among the workbenches, microscopes, measuring glasses, machines, tools, molecules, cells, etc., but is structured in the lecture hall among desks, books, exams, evaluations and theses. In Higher Education, novices encounter objects and subjects of knowledge in the transition from the lecture hall to the laboratory, and through them gain mastery of know-how and practical dexterity in a trajectory which is neither linear nor standardized. When they arrive in the laboratory, the novices already possess knowledge to be put to the test and experimented, they already have questions to ask and hypotheses to investigate: they have a theoretical experience of study, and when they arrive in the laboratory they very soon become those who sustain the research work. They immediately enter into the heart of authentic practice.

Margherita's story therefore allows us to observe the chain between learning and practical work experience. From it, we see how disciplinary knowledge, rigidly compartmented in scholastic learning (Engestom 1995), is disarticulated and becomes know-how incorporated through practical experience, which is not merely cognitive apprenticeship (Collins et al. 1987), but rather becomes incorporated practical knowledge. The laboratory becomes a pedagogical workplace where practices are co-participated between subjects and artifacts (Billett 2002). In the laboratory, the formal university curriculum is translated into practice: it is situated within the practice (Billett 2002: Billett 2011; Gherardi 1998) and made available as a socializing device for instructing the novice in the context of working activities. Within this pedagogical space, the novice learns through the senses and the body and through the sociomaterial mediation of humans and artifacts (Law 1987). In this way, he or she swiftly masters the rudiments of practice.

The learning practices which are activated in this pedagogical context deploy subjects, objects and the relationships between them, and this process produces a heterogeneous fabric of sociality, of which the novice becomes an integral part. The pedagogy activated in the scientific laboratory context fosters the co-existence of learning practices and academic interests, producing tension between codified knowledge and unstable expertise in evolution, between the procedural standards and artisan skills incorporated by both novices and experts. Only by integrating these two types of knowledge can a robust university training and qualification be achieved.

References

Atkinson, P., Coffey, A., Delamont, S., Lofland, J., & Lofland, L. (2001). (Eds.), *Handbook of ethnography*, London: Sage.

Billett, S. (2002). Toward a workplace pedagogy: Guidance, participation, and engagement. *Adult Education Quarterly, 53*(1), 27–43.

Billett, S. (2011). *Curriculum and pedagogic bases for effectively integrating practice-based experiences*. Sydney: Australian Learning and Teaching Council.

Bruni, A. (2013). "Technologically dense environments: What for? What next?" in tecnoscienza. *Italian Journal of Science & Technology Studies, 4*(2) (being printed).

Collins, H. (2010). *Tacit and explicit knowledge*. Chicago: University of Chicago Press.

Collins A., Brown J. *S.,* Newman S. E., (1987) Cognitive apprenticeship: Teaching the craft of reading, writing and mathematics (Technical Report No. 403), BBN Laboratories, Cambridge, MA. Centre for the Study of Reading, University of Illinois.

Czarniawska, B. (2007). *Shadowing and other techniques for doing fieldwork in modern societies*. Copenhagen: Business School Press.

Engestom, Y. (1995). Non scholae sed vitae discimus. Come superare l'incapsulamento dell'apprendimento scolastico. In A. M. Ajello, C. Pontecorvo, & C. Zucchermaglio (Ed.), (a cura di). *I contesti sociali dell'apprendimento*. Milano: LED.

Fenwick, T., & Edwards, R. (2010). *Actor network theory and education*. London: Routledge.

Fenwick, T., & Edwards, R. (2012). *Researching education through actor-network-theory*. London: Wiley-Blackwell.

Gherardi, S. (2000). Practice-based theorizing on learning and knowing in "organizations". *Organisation, 7*(2), 211–223.

Gherardi, S. (2001). From organizational learning to practice- based knowing. *Human Relations, 54*(1), 131–139.

Gherardi, S. (2006). *Organizational knowledge: The texture of workplace learning*. Oxford: Blackwell publishing

Gherardi, S. (2009). Community of pratice or practices of a community? In *The sage handbook of management learning, education, and development* (pp. 514–530). London: Sage.

Gherardi, S. (2011). Organizational learning: The sociology of practice. In M. Easterby-Smith & M. Lyles (eds), *The blackwell handbook of organizational learning and knowledge management* (pp. 43–65). Oxford: Blackwell.

Gherardi, S., Nicolini, D., & Odella, F. (1998). Toward a social understanding of how people learn in organisations: The notion of situated curriculum. *Management Learning, 29*(3), 273–298

Gherardi, S., Nicolini, D., & Strati, A. (2007). The passion for knowing. *Organization, 14*(3), 315–329.

Gibson, J. J. (1986). *The ecological approach to perception*. Hillsdale: Lawrence Erlbaum Associates.

Goodwin, C. (1994). Professional vision. *American Anthropologist, 96*(3), 606–633.

Hennion, A. (2004). Une sociologie des attachments. D'une sociologie de la culture une pragmatique de l'amateur. *Sociètès, 85*(3), 9–24.

Hutchins, E. (1995). *Cognition in the wild*. Cambridge: MIT Press.

Kaiser, D. (2005). *Pedagogy and the practice of science: Historical and contemporary perspectives*. Cambridge: MIT Press.

Knorr Cetina, K. (1997). *Sociality with objects: Social relations in postsocial knowledge societies*. *Theory, Culture & Society, 14*(1), 1–30.

Knorr Cetina, K. (1999). *Epistemic cultures: How the sciences make knowledge*. Cambridge: Harvard University Press.

Knorr Cetina, K. (2001). Objectual practice. In T. R. Schatzki, K. Knorr Cetina & E. von Savigny (Eds.), *The practice turn in contemporary theory* (pp. 175–188). London: Routledge.

Landri, P., & Viteritti, A. (2010). Tracing socio-materiality in education, Paper for Conference Theorising Education, First International Theorising Education Conference, Stirling Management Centre, University of Stirling, UK, June 24–26.

Latour, B. (1987). *Science in action. How to follow scientists and engineers through society*. Milton Keynes: Open University Press.

Latour, B. (2005). *Reassembling the social*. Oxford: Oxford University Press.

Latour, B., & Woolgar, S. (1979). *Laboratory life: The social construction of scientific facts*. Thousand Oaks: Sage.

Lave, J., & Wenger, E. (1991). *Situated learning. Legitimate peripheral participation*. Cambridge: Cambridge University Press.

Law, J. (1987). Technologies and heterogeneous engineering: The case of the Portuguese expansion. In W. E. Bijker, T. P. Hughes, & T. J. Pinch (Eds.), *The social construction of technical systems: New directions in the sociology and history of technology* (pp. 111–134). Cambridge: MIT Press.

Lynch, M. (1985). *Art and artifact in laboratory science: A study of shop work and shop talk in a research laboratory*. Boston: Routledge.
Nicolini, D., Gherardi, S., & Yanow (2003). *Knowing in organization. a practice-based-approach*. New York: M.E. Sharpe.
Orlikowski, W. J. (2007). Sociomaterial practices: Exploring technology at work. *Organization Studies, 28*(9), 1435–1448.
Polanyi, M. (1966). *The tacit dimension*. New York: Doubleday & Company Inc.
Sørensen, E. (2009). *The materiality of learning technology and knowledge in educational practice*. Cambridge: Cambridge University Press.
Star, L. S., & Griesemer, J. R. (1989). Institutional ecology, 'translations' and boundary objects: Amateurs and professionals in Berkeley's museum of vertebrate Zoology, 1907–39. *Social Studies of Science, 19*(3), 387–420.
Strati, A. (2007). Sensible knowledge and practice-based learning. *Management Learning, 38*(1), 61–77.
Viteritti, A. (2012). "*Sociomaterial Assemblages in learning scientific practice: Margherita's first PCR*" in TECNOSCIENZA. *Italian Journal of Science & Technology Studies, 3*(1), 29–48 http://www.tecnoscienza.net/index.php/tsj/article/view/91.
Viteritti, A. (2013). "It's the body (that does it)! The production of knowledge through body in scientific learning practice". *Scandinavian Journal Of Management, 29*(4), 367–376 (Edited by S. Gherardi, S. Merilainen, A. Strati, A. Valtonen, Special Issue "Body, senses and knowing in organization. Stockholm: Elsevier Science Publishing Company).
Yakhlef, A. (2010). The corporeality of practice-based learning. Organization Studies, 31(4), 409.