

Applications of Mathematics in Models, Artificial Neural Networks and Arts

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Editors

Applications of Mathematics in Models, Artificial Neural Networks and Arts

Mathematics and Society

 Springer

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Preface

The story of this book begins with the conference of 8–9 December 2007 entitled “Mathematics and Society” celebrating the 40 years of *Quality and Quantity, International Journal of Methodology* founded in 1967, under the auspices of Paul F. Lazarsfeld, by editor Vittorio Capecchi and co-editor Raymond Boudon. The journal at present is published by Springer Science & Business Media, Dordrecht. The editor is Vittorio Capecchi, the co-editors are Raymond Boudon and Massimo Buscema. It is a bimonthly publication and it is available online. In the first 10 years, *Quality and Quantity, International Journal of Methodology* published articles by authors writing from Europe and the United States, but in the last 10 years, a growing number of authors who present essays with mathematical models are living in Asia.

The conference of 8–9 December was promoted by the University of Bologna (at the conference, chancellor Pier Ugo Calzolari was present) and the AIS (Italian Association of Sociology) with Departments of Education, Mathematics and Natural and Physical Sciences and the Faculty of the Sciences of Education of the University of Bologna and with the Publishing House Springer (Myriam Poort was present). The success of the conference has produced the original project of this book edited by Vittorio Capecchi with Massimo Buscema, Pierluigi Contucci, Bruno d’Amore.

The book presents a historical introduction (by Vittorio Capecchi) followed by three parts. In the first part *Mathematics and Models* (coordinated by Pierluigi Contucci), mathematical models to study society elaborated in Department of Mathematics and Physics are compared to others that were elaborated in Department of Sociology and Economics. In the second part *Mathematics and Artificial Neural Networks* (coordinated by Massimo Buscema), the applications of ANNs to the social sciences are analysed in several directions and in the third part *Mathematics and Art* (coordinated by Bruno D’Amore), the essays explore the ways in which mathematics and arts relate each other.

In historical introduction, Capecchi analyses in what manner the relation between mathematics and sociology has changed. Three phases are presented: (1) Paul F. Lazarsfeld’s choices concerning theory, methodology and mathematics as applied to sociological research; (2) the relations between mathematics and sociology from statistical methods to artificial society and social simulation models; (3) the new possibilities offered to sociology though by artificial neural networks. Then the

changes in the methodological problems linked to the relation between mathematics and sociology are analysed together with the changes in the most important paradigm utilized in sociological research, namely the paradigm of objectivity; the paradigm of action research/co-research and the paradigm of feminist methodology. At the end of the introduction, some new possible synergies are presented.

The first part of the book coordinated by Pierluigi Contucci deals with models coming from the community of mathematicians and physicists as well as from scholars in sociology, economy and cognitive psychology. The leading theme of the mathematical–physical approach concerns the identifications of those model features which are responsible for the collective behaviour as derived from individual contribution for large numbers of them. The paper by P. Contucci, I. Gallo and S. Ghirlanda studies the effect of the interaction between two cultures and the possible scenarios appearing including the phase transitions. The methods used are those coming from statistical mechanics. The paper by Bolina gives a transparent introduction to the statistical mechanics general methods for those readers who are not familiar with that discipline. The paper by F. Gallo et al. applies the method introduced in the previous papers to the study of the climate change and energy virtuous behaviour especially oriented to the recommendation to public policy makers. The paper by A. Borghi et al. explains the necessity of embodied models in cognitive psychology. The paper by Robert Smith (Social Structural Research, Inc., Cambridge, MA) presents the possibility to analyse with stronger mathematical models *The Academic Mind* by Paul F. Lazarsfeld; Simone Sarti and Marco Terraneo (University of Milano-Bicocca) apply a multilevel regression technique to validate a social stratification scale; Claudio Gallo (Crs4, Cagliari) discusses the mathematical models of financial markets.

The second part of the book, coordinated by Massimo Buscema, presents essays by the Semeion Group (Massimo Buscema, Giulia Massini, Guido Maurelli, Stefano Terzi) and by Enzo Grossi (Bracco SpA, Milano), Pierluigi Sacco (IUAV, University of Venezia), Sabina Tangaro (Istituto Nazionale Fisica Nucleare, Bari). Artificial adaptive systems (AASs) are a new area of the modern applied mathematics. The main goal of AAS is to generate models from data. So, AASs are systems able to make the different models explicit, hidden in the real world. To do that, AASs present a set of specific features:

1. AASs are completely data driven or more precisely, the less the free parameters they have to presume, the better.
2. AASs generate a specific model only during their active interaction with the data. So they are bottom-up systems and they produce a data model as an end point of an iterative and a feedback loop process. This means that the final model of the data emerges automatically during the process itself. Consequently, they are dynamic systems, where the time of their learning and/or evolutionary process is part of the final model.
3. During their learning and/or evolutionary process, they process all the variables of the data in parallel. So, at the end of this process, each variable has been

defined by its global interaction with all the others (many-to-many relationships); so, theoretically, every order of variable interaction should be coded.

4. AAS has to be able to code all the consistent non-linearity hidden in the data.
5. During the learning and/or the evolutionary process, both the variables and the records (points) of the data set work as agents. This means that they interact in active way among them and with the basic parameters of the AAS equations.
6. AAS, to be validated, has to follow specific validation protocol and procedures, very similar to the procedures used in experimental physics.

In this part of the book we show new AAS algorithms, recently designed in AAS basic research, and their experimental application in real-world problems: bio-medicine and security.

These two applicative fields seem to be uncorrelated. Partially this is true. And so the application of the same algorithms to different areas is a good test to prove their capability to be really “data driven”. From another point of view, bio-medicine and security are linked; both represent tough real problems, wherein the gold standard is very often grounded. Consequently, it is easy to analyse the performances of our AAS. Bio-medicine and security are also very sensitive “ethic” subjects; in the first, we try to defeat the disease, in the second one, we try to cope with violence and illegality, an impressive social disease.

The third part of the book, coordinated by Bruno d’Amore, presents essays on the relation between mathematics and art. Amongst the most widespread convictions, and not only in a low cultural profile perspective, there is the following: art (in all of its aspects, but here I will focus on figurative art) is the reign of freedom and fancy, whereas mathematics is that of formalism and rigour.

This approach refers to a position according to which we are dealing with two opposite worlds, with no cultural unity. Nevertheless the aforementioned four terms (freedom and fancy, formalism and rigour) do have common deep ties and are all produced by human beings, by their need to create and communicate.

Since the Renaissance there are examples of artists–mathematicians in which such terms are indissolubly bound, reinforcing each other; it is well known that Albrecht Dürer travelled in Italy to gain knowledge of the “scientific” art, widespread in the Peninsula and not yet in Bavaria, and to take courses as a geometry student at the *Alma Mater*; without rigorous knowledge, he said, art is an empty fancy and a blindly accepted practice.

Freedom and fancy must lay on a rigorous basis that gives them *sense*; otherwise it is *ignis fatuus*, uselessness, illogical. On the other hand, today it is well known that the first gift required by any high-level mathematician is fancy. Several mathematicians stated that a person quitted mathematics and became a poet (or a painter) because he or she was not fancy enough. Furthermore, when we say that a chess player plays with fancy, we do not mean he or she does not follow the rules of that game strictly but that he or she follows them conceiving unexpected and creative strategies.

We do not want to astonish the reader with these statements; in fact, we just want to convince the few that should still be so naive to believe these trivial dichotomies.

So if it is true, as it is, that many artists in centuries (more and more often at the present time) turned to mathematics as a source of inspiration or as an object of their pictorial practice, it is also true that many mathematicians (more and more often at the present time) did not despise to look at figurative art, with very different means, instruments and objectives, as an interesting and significant field of research and cultural speculation.

We tried to reproduce here the variety of these approaches. Bruno d'Amore (his essay is about mathematics and figurative art) has invited the following colleagues to discuss them from many points of view that are perfectly entangled, but each of them following specific and distinct lines, hoping to offer a significant variety of such interests: Igino Aschieri and Paola Vighi (University of Parma), *From Art to Mathematics in the Paintings of Theo van Doesburg*; Giorgio Bagni (University of Udine), *Mathematics, Art, and Interpretation: A Hermeneutic Perspective*; Giorgio Bolondi (University of Bologna), *Points, Line and Surface. Following Enriques and Kandinsky*; Michele Emmer (University of Roma I), *Visibili armonie: The Idea of Space from "Flatland" to Artistic Avant-garde*; Franco Eugeni and Ezio Sciarra (University of Teramo), *Mathematical Structures and Sense of Beauty*; Monica Idà (University of Bologna), *Visual Impact and Mathematical Learning*; Marco Pierini (University of Siena), *Art by Numbers. Mel Bochner, Roman Opalka and other Filaritmici*; Aldo Spizzichino (CNR of Bologna), *My Way of Playing with the Computer*; Gian Marco Todesco (Digital Video SpA), *Four-Dimensional Ideas*.

The essays presented in these three parts are interesting not only for their contribution to mathematical methodology and to the methodology of social research but also for other two important directions of action research: (1) technological innovations regarding the quality of life (climate changes through efficient energy, mathematical models against criminality, mathematical models for medicine and so on) and (2) technological innovations for creativity (the papers of the section *Mathematics and Art* are in the direction of projects as the *Creative Cities Network* of UNESCO).

Finally this book is useful not only for those who make use of mathematics in the social sciences but also for those who are engaged in the diffusion of technological innovation to improve life quality and to spread creativity in all directions of the arts.

Bologna, Italy
 Roma, Italy
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Vittorio Capecchi
 Massimo Buscema
 Pierluigi Contucci
 Bruno D'Amore

Contents

1 Mathematics and Sociology	1
Vittorio Capecchi	

Part I Mathematics and Models

2 Equilibria of Culture Contact Derived from In-Group and Out-Group Attitudes	81
Pierluigi Contucci, Ignacio Gallo, and Stefano Ghirlanda	
3 Society from the Statistical Mechanics Perspective	89
Oscar Bolina	
4 Objects, Words and Actions: Some Reasons Why Embodied Models are Badly Needed in Cognitive Psychology	99
Anna M. Borghi, Daniele Caligiore, and Claudia Scorolli	
5 Shared Culture Needs Large Social Networks	113
Luca De Sanctis and Stefano Ghirlanda	
6 Mathematical Models of Financial Markets	123
Claudio Gallo	
7 Tackling Climate Change Through Energy Efficiency: Mathematical Models to Offer Evidence-Based Recommendations for Public Policy	131
Federico Gallo, Pierluigi Contucci, Adam Coutts, and Ignacio Gallo	
8 An Application of the Multilevel Regression Technique to Validate a Social Stratification Scale	147
Simone Sarti and Marco Terraneo	
9 The Academic Mind Revisited: Contextual Analysis via Multilevel Modeling	163
Robert B. Smith	

Part II Mathematics and Neural Networks

- 10 The General Philosophy of the Artificial Adaptive Systems** 197
Massimo Buscema
- 11 Auto-contractive Maps, the H Function, and the Maximally
Regular Graph (MRG): A New Methodology for Data Mining . . .** 227
Massimo Buscema and Pier L. Sacco
- 12 An Artificial Intelligent Systems Approach to Unscrambling
Power Networks in Italy’s Business Environment** 277
Massimo Buscema and Pier L. Sacco
- 13 Multi-Meta-SOM** 313
Giulia Massini
- 14 How to Perform Data Mining: The “Persons Arrested” Dataset . .** 349
Massimo Buscema
- 15 Medicine and Mathematics of Complex Systems: An
Emerging Revolution** 415
Enzo Grossi
- 16 J-Net System: A New Paradigm for Artificial Neural
Networks Applied to Diagnostic Imaging** 431
Massimo Buscema and Enzo Grossi
- 17 Digital Image Processing in Medical Applications, April 22, 2008 .** 457
Sabina Tangaro, Roberto Bellotti, Francesco De Carlo,
and Gianfranco Gargano

Part III Mathematics and Art

- 18 Mathematics, Art, and Interpretation: A Hermeneutic Perspective** 477
Giorgio T. Bagni
- 19 Point, Line and Surface, Following Hilbert and Kandinsky** 485
Giorgio Bolondi
- 20 Figurative Arts and Mathematics: Pipes, Horses, Triangles
and Meanings** 491
Bruno D’Amore
- 21 The Idea of Space in Art, Technology, and Mathematics** 505
Michele Emmer
- 22 Mathematical Structures and Sense of Beauty** 519
Raffaele Mascella, Franco Eugeni, and Ezio Sciarra
- 23 Visual Impact and Mathematical Learning** 537
Monica Idà and Cécile Ellia

24	Art by Numbers	547
	Mel Bochner, Roman Opalka, and other Philarithmics	
25	My Way of Playing with the Computer: Suggestions for a Personal Experience in Vector Graphics	555
	Aldo Spizzichino	
26	Four-Dimensional Ideas	587
	Gian M. Todesco	
27	From Art to Mathematics in the Paintings of Theo van Doesburg	601
	Paola Vighi and Igino Aschieri	
	Author Index	611

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Chapter 1

Mathematics and Sociology

From Lazarsfeld to Artificial Neural Networks

Vittorio Capecchi

Abstract In this historical introduction Capecchi analyses in what manner the relation between mathematics and sociology has changed. Three phases are presented: (a) Paul F. Lazarsfeld's choices concerning theory, methodology and mathematics as applied to sociological research; (b) the relations between mathematics and sociology from statistical methods to artificial society and social simulation models; and (c) the new possibilities offered to sociology though by artificial neural networks. Then the changes in the methodological problems linked to the relation between mathematics and sociology are analysed together with the changes in the most important paradigm utilized in sociological research namely the paradigm of objectivity; the paradigm of action research/co-research and the paradigm of feminist methodology. At the end of the introduction, some new possible synergies are presented.

The first issue of the periodical *Quality and Quantity*, edited by Vittorio Capecchi with Raymond Boudon as advisory editor, was published in English in January 1967, under the auspices of Paul F. Lazarsfeld (PFL). PFL thought that it was time that the relation between mathematics and sociology started to spread in Europe also (the periodical was in fact published with the subtitle *European Journal of Methodology*). I met PFL in 1962 in Gössing (Austria) during a seminar on *mathematics and social sciences*¹ (PFL had previously written to some Italian departments of statistics to find out whether there were young scholars trained in mathematics and sociology. At the time I had just got a degree at the Bocconi University in Milan with Francesco Brambilla and Angelo Pagani, with a dissertation entitled “Application of Markov Chains to Social Mobility”). After the seminar, I decided to edit PFL's works in Italian² and subsequently began to do research at the Bureau of

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¹The proceedings of the seminar were published in Sternberg et al. (1965).

²Lazarsfeld (1967).

Applied Social Research at the Columbia University, at the time under the direction of PFL, who used to collaborate with Robert K. Merton. In Paris, thanks to PFL, I met Raymond Boudon, who at the time was editing PFL's works in French, and together we decided to plan a periodical on the interrelation between mathematics and sociology.

The first issue of *Quality and Quantity* was published by a small Italian publishing house (Marsilio in Venice), thanks to the help of the architect Paolo Ceccarelli, who, at the time, owned some shares in Marsilio. The cover of the issue – which has always remained the same – was created by a Venetian designer. After 2 years, in 1969, the periodical started to be published by Il Mulino in Bologna, thanks to Giovanni Evangelisti, who thought that PFL's work was going to become a cornerstone of Italian sociology. Starting from 1962, the periodical was published by Dutch publishing houses (Elsevier, Kluwer and Springer). Nowadays, Springer publishes six issues a year which are also available online, with Raymond Boudon and Massimo Buscema as co-editors. In all those 40 years, *Quality and Quantity* has been very well organized by the editorial secretary Dolores Theresa Sandri.

The relation between mathematics and sociology has a long history which begins in Europe, as it is briefly illustrated by PFL (1962, p. 761) as follows:

Sampling methods were derived as a sequence to Booth's survey of life and labour in London. Factor analysis was invented by the Englishman, Spearman. Family research, with special emphasis on quantification, come of age with the French mineralogist Le Play: Gabriel Tarde advocated attitude measurement and communication research (. . .) The idea of applying mathematical models to voting was elaborately worked out by Condorcet during the French Revolution. His contemporaries, Laplace and Lavoisier, conducted social surveys for the Revolutionary Government, and their student, The Belgian, Quételet, finally and firmly established empirical social research under the title, "phisique sociale" (. . .). In Italy, during the first part of this century, Niceforo developed clear ideas on the use of measurement in social and psychological problems brilliantly summarised in his book on the measurement of progress. The German could claim a number of founding fathers: Max Weber was periodically enthusiastic about quantification, making many computations himself; Toennies invented a correlation coefficient of his own; and during Easter vacations, von Wiese regularly took his students to villages so that they could see his concept about social relations acted out in peasant families.

In a long article dedicated to the relation between mathematics and sociology, PFL (1961) wrote that such a relationship can be divided into three phases; each phase is marked by the work of a leading scholar: (1) *government statistics* with important contribution by the German philosopher Hermann Conring (1606–1681); (2) *phisique social* with contributions by Belgium astronomer and statistician Adolphe Quételet (1796–1874) and (3) the *observation method* with contributions by the French mineralogist Frédéric le Play (1806–1882). The most representative scholar of phase that followed – the *Methodology of Sociological Research* – was certainly the sociologist and mathematician Paul F. Lazarsfeld (1901–1976). In 1954, in his introduction to *Mathematical Thinking in the Social Sciences*, PFL makes the following comments concerning the relation between mathematics and sociology:

Why mathematics is useful for sociology: (i) mathematics contributes to clarity of thinking and, by permitting better organization of available knowledge, facilitates decisions as to

needed further work; (ii) how do we weave back and forth from empirical observation to the parameters of the underlying model incorporating our theoretical assumptions, in terms which are always in part probabilistic; (iii) There is little doubt that a trend toward formalization will profitably bring together a variety of pursuits in the behavioral science which, at the moment, have little contact.

Three roads seem promising; (i) We need people who are trained both in mathematics and in some sector of social sciences; (ii) At the same time, actual investigations have to be carried on; (iii) In addition to training and creative work, there is a third road. We need investigations which clarify in a more general way the possible relations between mathematics and the social sciences.

The future of relation mathematics/sociology; How the role of mathematical thinking in the social sciences will evolve is more difficult to predict, because neither mathematics nor social sciences is unchangeably fixed.³

In this historical introduction I have tried to reconstruct the relation between mathematics and sociology, keeping in mind the last 40 years of *Quality and Quantity* and the following three phases: (a) PFL's choices concerning theory, methodology and mathematics applied to the paradigm of objectivity; (b) the relations between mathematics and sociology from statistical methods to artificial society and social simulation; (c) the new possibilities offered to sociology by artificial neural networks.

1.1 Theory, Methodology and Mathematics: the Choices of Paul F. Lazarsfeld

Paul Felix Lazarsfeld (PFL) is best known for having used in the United States (and in Europe) quantitative methods which were opposed to the qualitative methods of the Chicago School. The reception of his works in the United States, France and Italy⁴ has however rightly stressed that his contribution is more complex than this. PFL's choices concerning sociological theory, methodology and mathematics can be summed up as follows:

- *Subordination of research to theory.* In order to understand PFL's choices concerning sociological theory, it should be remembered that during the 1950s and the 1960s in the United States the "grand theory" of Talcott Parsons was opposed to a "middle range theory", proposed by Robert Merton. PFL chose the method by Merton and, as noted in PFL (1953), his programme had the following goals: (a) to find the causes of individual actions and (b) to understand mutual modifications that take place as a consequence of interactions. PFL's work is in line with his theoretical objectives. He in fact was engaged, or participated, to various researches concerning individual behaviour in specific situations (unemployment

³Lazarsfeld (1954), pp. 3–5, 8, 10, 16. The quotations from PFL (1954) have been organized in a different way.

⁴In the United States: Merton et al. Eds. 1979; in France: Lautman and Lécuyer Eds. 1998; in Italy: Campelli Ed. 1999.

in *Die Arbeitslosen von Marienthal*, the Second World War in *The American Soldier*, the McCarthyism in *The Academic Mind*) and mechanisms subordinated to specific choices (the political vote in *The American Voter* or consumers' choices in *Personal Influence*), with the aim to evaluate the effect of interactions of the behaviour of single people. As noted by Robert Merton (1998, p. 174), "It was only the topics that varied endlessly(. . .). But at their conceptual core most of those varied topics were instances of a crucial type of action: the making of choices ore, in somewhat extended sense, the arriving at decisions". In brief, research is subordinated to theoretical construction.

- *Subordination of methodology to research.* The methodology to carry out this programme is based on the paradigm of objectivity. According to PFL the Chicago School cannot be defined as a scientific one, because it proposed qualitative methods such as participating observations experimented by anthropologists, among whom was Malinowski. As noted by William Foote Whyte in his book *Street Corner Society* (1943, p. 356–357): "It would be impossible to map out at the beginning the sort of study I eventually found myself doing". His work "depended upon an intimate familiarity with people and situation" and this "intimate familiarity" was necessary "to understand the group" only through observing how it changed through time. Foote Whyte thought that there were risks in this kind of research (if the scholar at the beginning is a non-participating observer, but later on, when he has been accepted by the group, he becomes more and more participating and less and less of an observer), but these were still acceptable risks because they led to a better knowledge of people and communities that were the object of the study.

PFL prefers to run other kinds of risks and uses the paradigm of objectivity. From the point of view of the distinction between standpoint epistemology, methodology and research methods,⁵ this *paradigm of objectivity* can be defined as follows:

1. *Standpoint epistemology.* Sociological research has the goal to formulate theories (explanations) on attitudes and behaviours of people who have to make choices with the most possible objectivity.
2. *Methodology.* In order to reach this objective, research is separated by actions that could derive from explanations obtained through research. The explanations are considered scientifically valid if the answers (information) given by the subjects of the research are "objective". An increased objectivity can be obtained if

⁵In this paper the term *paradigm*, in the sense attributed to it by Kuhn, has been used for the following: (a) standpoint methodology; (b) methodology; (c) research methods. The definitions are by Sandra Harding (2004, p. 44; 1987, p. 2): *standpoint epistemology* "sets the relationship between knowledge and politics"; *methodology* is "a theory and analysis of how research does or should proceed"; *research method* "is a technique for (or way of proceeding in) gathering evidence. (...) In this sense there are only three methods of social inquiry: listening to (or) interrogating informants, observing behaviour or examining historical trace and records".

the researcher does not influence the answers (information) given by the subjects of the research.

3. *Research methods.* Valid methods of research are only two: those in which there is no interaction on the part of researcher with the subject of research or those in which the interaction happens through a group of professional interviewers who use a scientific method.

The objectivity paradigm, however, is not used by PFL in a rigid and reductive way and, in *The Academic Mind*, its use in the survey leads to results that make this research closer to the one of the Chicago School. The steps of a survey, according to PFL (1958, pp. 101–104), are four:

1. *Imagery.* The flow thought and analysis and work which ends up with a measuring instrument usually begins with something which might be called imagery. Out of the analyst's immersion in all the detail of a theoretical problem, he creates a rather vague image or construct. (...)
2. *Concept specification.* The next step is to take this original imagery and divide it into components. The concept is specified by an elaborate discussion of phenomena out of which it emerged. We develop "aspects", "components", "dimensions" or similar specification. (...)
3. *Selection of indicators.* After we have decided on these dimensions, there comes the third step: finding indicators for the dimensions. (...)
4. *Formation of indices.* The fourth step is to put Humpty Dumpty together again (...) because we cannot operate with all those dimensions and indicators separately.

In *The Academic Mind*, one should however add a fifth step:

5. *A political use of quantitative methodology and mathematics.* Quantitative methods and the use of mathematics present results in a more "objective" way and in this way they can be used to protect the "subjectivity" of the researcher and allow her/him to express subjective evaluations that do not conform with the contemporary political climate.

This fifth step, never explicitly declared but nevertheless practised by PFL, stresses the way in which he always subordinates methodology to the goals of theory and research. As Jacques Lautman and Bernard-Pierre Lécuyer have noted (1998, p. 17), PFL's methodology is not an end to itself, because "the use of methodological innovation happened only when one encountered difficulties with theory".

- *Subordination of mathematics to methodology.* PFL's use of mathematics, within his proposed methodology for sociological research, follows two directions: (a) a direction that is subordinated to research needs and sociological theory ($S \rightarrow M \rightarrow S$, where S = sociology and M = mathematics) and (b) a direction in which mathematics has its own autonomy of elaboration, even though this is applied to sociology ($M \rightarrow S \rightarrow M$). PFL's contribution mainly follows the first direction; here the limits of mathematics are two: (i) mathematics models and

methods are mainly linear with only few exceptions and (ii) it is not possible to deal with variables at the level of the nominal scale, ordinal scale or interval scale at the same time.⁶

In a sociological research, such as the survey, items at the nominal level (gender distinctions, political and geographical origins, etc.), at the ordinal level (education record), at the level of the interval scale (test result or attitude scales) and on the ratio scale (age, recurrence of behaviours, and so on) are all present at the same time. As a consequence, it is not possible to treat all items of a sociological research according to the same methods or mathematical model. Possible solutions are the following: (i) reduce part of the items in dichotomous variables and (ii) reduce part of the items in variables on the interval scale. In this way, scores between 1 and 4 are adopted in order to make items on the ordinal scale (education record) and items on the ratio scale (age) homogeneous; (iii) try to construct indices that summarize more items.

The result was that, even in PFL's most elaborated researches, mathematical applications are always realized by limited number of items and the research results are summarized in a limited number of indices. PFL's choices will be analysed with reference to three researches (*Die Arbeitslosen von Marienthal*, *Personal Influence*, *The Academic Mind*), in order to understand the ways in which sociological research can be classified.

1.1.1 Types of Sociological Research: Some Suggestions

Some suggestions concerning the classification of sociological research coordinated by PFL (or undertaken following his instructions) are illustrated in Tables 1.1, 1.2 and 1.3. Table 1.1 has been presented by Hanan Selvin (1979) to define the different study aim of a research which uses two dimensions: (a) there is a distinction between researches that take into account data already gathered (such as censuses or electoral results), which must be analysed without any possibility of modifying them, and researches that analyse data gathered on a new population of subjects that are interviewed and (b) there is a distinction between explicative researches, concerning causes, and researches that are only descriptive.

⁶Warren S. Torgerson (1958) gives the following definitions for the four types of scales: (i) *nominal scale*: when between the two elements A and B of the same variable, it is possible to indicate only the relation $A = B$, $A \neq B$; (ii) *ordinal scale*: when between two elements of the same variable, it is possible to indicate the relations $A < B$, $A = B$, $A > B$; (iii) *interval scale*: when the scale has no natural origin and operations such as $A : B$, $A \times B$ are possible, but the origin and units of measure are arbitrary (as in test scores); (iv) *ratio scale* when the scale has natural origin (as in the age variable) and operations such as $A : B$, $A \times B$ are possible.

Table 1.1 Types of sociological research: study aim

Study aim	The investigator seeks to describe an antecedent defined population	The investigator seeks to describe a new population
The investigator is interested in causality	Descriptive explanatory S. A. Stouffer (1955) <i>Communism, conformity and civil liberties.</i>	Purely explanatory studies M. Jahoda, PFL and H. Zeisel (1933) <i>Die Arbeitslosen von Marienthal.</i>
The investigator is not interested in causality	Purely descriptive P. M. Blau and O. D. Duncan (1962) <i>The American occupational structure.</i>	Nonstudy Example : <i>How youth feel about depression</i>

Source: Selvin (1979)

Table 1.2 Types of sociological research: methodological options with the paradigm of objectivity

Methodological options	No interaction	Interaction with interview
Quantitative methods	Observation of quantitative behaviours and utilization of statistics (example: <i>Die Arbeitslosen von Marienthal</i> (1933))	Survey (examples: <i>Personal Influence</i> (1955); <i>The Academic Mind</i> (1958))
Qualitative methods	Observation of qualitative behaviours and utilization of letters, diaries (examples: <i>Die Arbeitslosen von Marienthal</i> (1933); <i>Asylums</i> (1961))	Survey with open items (example: <i>The Academic Mind</i> (1958))

Table 1.3 Types of sociological research: sponsors and object of research

Research sponsor	Object of research			
	Towards “top”	Intermediary	Towards ‘bottom’ Type I	Towards “bottom” Type II
Financial research sponsor not using results	1	2	3	4
Financial research sponsor using results	5	6	7	8
Non-financial research sponsor chosen by enquiry group	9	10	11	12

Source: Capecchi (1972, 1981)

Methodological choices within the paradigm of objectivity lead to two dimensions indicated in Table 1.2: (c) a greater/smaller interaction between the researcher and the subjects of the research and (d) the greater or lesser possibility to use quantitative or qualitative methods of analysis.

Dimension (c) distinguishes between two kinds of research: (i) research with no interaction and (ii) research in which the only possible interaction is between the professional interviewer and the subjects of the research.

Among the researches in which there is no interaction with the subjects of the research are statistics, letters, diaries, etc. or cases in which people are observed without being aware of it. *Die Arbeitslosen von Marienthal* and *Asylums* (1961) by Erving Goffman are part of the latter. In *Asylums* the researcher was hired for 6 months as a masseur by a psychiatric in order to observe what was going on without influencing the interrelations among patients, nurses and doctors. It should be stressed that *Asylums*, which is realized without any interaction between the research co-ordinator and the subjects of the research, has produced very relevant changes in psychiatric practice (in Italy its translation, by Franco Basaglia, has been of major importance to start a new way to practise psychiatry). Researches without interaction as well as those based on interviews use quantitative and qualitative methods, as clearly shown by PFL's researches, which will be considered in the next section. However, it should be considered that if one chooses the paradigm of objectivity, some qualitative methodological strategies may be excluded.

In Table 1.3, shown in Capecchi (1972, 1981), researches are classified taking into account of the following: (e) the sponsor who finances the research and (f) the level (measured by the researcher) in which people and object of the research are collocated. This table was proposed in a period in which radical sociology was popular in the United States and caused worries about the possible negative role played by the sponsor and the tendency of sociological research not to take into account economic and political powers.

The research sponsor cannot be interested in using the results (this is the case of *The Fund for the Republic*, an emanation of the *Ford Foundation*, which sponsored for *The Academic Minds*) or he may be interested in using results (for example this is the case of the social democratic party in Vienna, which sponsored the *Arbeitslosen von Marienthal*, or Macfadden publications, which sponsored for *Personal Influence*). The sponsor can be a non-financial subject, when he helps the research but does not finance the research group, which therefore works for free.

Research can be different according to the kind of relation that is established between the researcher and the people, object of the research. Researchers can study power; they can study people that are, like themselves, university professors or they can study people that have less power and influence. In this latter case, two situations should be distinguished: (1) type I in which the asymmetrical relation is mainly due to social/economic variables (the unemployed in *Marienthal*, women interviewed in *Personal Influence*) and (2) type II in which the asymmetrical relation depends on other variables, such as gender, race or psychical condition (for example the patients of the psychiatric hospital studied by Goffman, etc.)

1.1.2 Die Arbeitslosen von Marienthal (1932)

In 1933, Franklin Delano Roosevelt becomes president of the United States of America; in the same year, Adolf Hitler becomes the German chancellor of the new Reichstag and begins his Nazi dictatorship. In 1932, *Die Arbeitslosen von Marienthal* is published. It belongs to PFL's Viennese period, studied by Hans Zeisel (1979), Anton Pelinka (1998), Francois Isambert (1998) and Marie Jahoda (1998). This book was published with Marie Jahoda and Hans Zeisel by the Centre of Applied Psychology, directed by PFL and financed by the Rockefeller Fund and the social democratic party of Vienna.

The objective of the research was to study the effects of unemployment on the people of Marienthal, a small industrial village in the outskirts of Vienna. The total inhabitants were 478 families, three quarters of these were fully unemployed, due to the fact that a cotton industry – Todesko, the only source of employment in the area – had closed. This is research 7 in Table 1.3. Thanks to the psychologist Marie Jahoda, the first wife of PFL, the research focused on the relationship between women and men in family life, on the way families spent their free time, the way they search employment, etc. This research was defined by its authors as an *immersion* research (sich einleben); the methodological choice of non-interaction with the people in Marienthal was taken in order to reach more objective results and was influenced, as PFL wrote (1971), by Karl Marx. Individual and contextual features were considered; analysis were mainly quantitative, based on official statistics (population statistics, complaints presented to the industrial commission, electoral results) and other kinds of data (the amount of money spent in the consumers' cooperative, the number of books borrowed from the local library, the number of subscriptions to periodicals). Another kind of survey was done; behind the window at midday sharp, the passers-by were observed to quantify the pace and the length of conversation of men and women that were going home.

It was also decided to observe the behaviour of men and women of Marienthal using qualitative methodologies. The research team organized the so-called "Clothes Project" (the team gave out 200 hundred pieces of clothes to the poorest families and in order to justify these presents they asked them to answer some questions), a "Medical Treatment Project" (the team was joined by an obstetrician and a paediatrician to give out, if necessary, free medicines), and two courses for women: one of model drawing to provide professional requalification for the less young ones and a gym course for the younger women.

The team tried to be as objective as possible, and the inhabitants of this little village started to consider it as a group of people who worked for the government to help them (by organizing courses, giving aid, etc.) and not as researchers. Even when the team used essays by school children (in exchange for Christmas presents), children thought that these were part of their routine homework.

The results led Jahoda, PFL and Zeisel to formulate a theory that was built step by step so that it was only at the end of the research that "essential ideas on the effects of unemployment emerged". The relations between the main variables were shown, and, as noted by Françoise Isambert (1998), they formed a

circular interpretative model, in which unemployment represented its beginning and its end: unemployment activates a “process of degradation” which aggravates, within a negative spiral, the problems about finding a job. Families were classified into four groups: resigned (48%), apathetic (25%), actives (16%) and desperate (11%). According to this scheme by Isambert, there are therefore various levels of degradation families can find themselves in (ranging from resignation to desperation). However, there is also a “deviant minority”: families defined as actives that try to find new solutions.

This research was highly valued in the United States by politically engaged sociologists such as Robert and Helen Lynd. The Lynds had already published *Middletown* (1929) and were influenced by PFL when later on they wrote *Middletown in Transition* (1937).

1.1.3 Personal Influence (1955)

1955 was the year of Martin Luther King. In that year in Montgomery, Alabama, Rosa Parks, a middle-aged lady, decided to rebel against black segregation, which obliged black people to sit in the back of buses, even when seats in the front were free. Rosa Parks sat in the front seats of a bus in Montgomery and for this reason she had to pay a \$10 fine. This event convinced Martin Luther King, who in 1955 has just received his Ph.D. in theology from Boston University, to become the leader of a pacifist movement for the rights of blacks. He started to boycott buses and in 1956 a sentence of the US Supreme Court declared segregation on buses unconstitutional.

Personal Influence, published in 1955 by PFL in collaboration with Elihu Katz, was financed by the research office of the Macfadden publications to understand how to organize an advertisement campaign (in Table 1.3, it is number 7 research). In this case, the sponsor used the results of the research for market purposes (while in *Die Arbeitslosen von Marienthal* the socialist party intended to use the results to fight back unemployment). This research is made in the period when Lazarsfeld was active. He had arrived in the United States in 1933 with a Rockefeller fellowship and as part of a wide intellectual migration⁷ from territories occupied by the Nazi [on this particular period, see essays by Christian Fleck (1998), Robert Merton (1998), Seymour Lipset (1998)]. The aim of *Personal Influence* was to analyse the influence of mass media on women consumers. PFL wanted to verify the theory of “two steps flow of communication”, according to which the majority of women are not directly influenced by mass media but by a net of opinion leaders that are part of their relations. The method for such verification consisted of three surveys done between the autumn of 1944 and the spring of 1945, just before the end of the Second World War. The study focused on some consumer choices (food, household products, movies and fashion) and the opinions on social and political issues

⁷See the article by PFL (1969).

expressed by women of Decatur, a city of about 60,000 inhabitants in the Middle West chosen to represent “average” behaviours.

In this work, relations between men and women were not taken into account and only individual variables were considered. For mathematical elaboration of results, the analysis of the latent structure was also used, and in the appendix “On the construction of indices”, the procedures that led to a summary of the main results were illustrated. These were divided into four indices: gregariousness, social status, importance and opinion leadership. When the study was published, PFL was criticized for having chosen market research in a period in which sociologists were mainly interested in fighting back what Martin Luther King called the three demons: poverty, racism and militarism. As Seymour Martin Lipset (1998, p. 264) noted:

To Lynd and to radical students like myself, however, the fact that Paul and his Bureau of Applied Social Research (formerly the Office of Radio Research) were so involved in market research, in studies supported by the radio networks, or advertising agencies, seemed like sell-outs. We knew, or I should rather say, I knew, that I could learn much from Paul and Bureau type research, essentially survey technique. But I and others refused to be seduced by what seemed to us to be the flesh-pots of capitalism.

There were two problems in *Personal Influence*: (1) the choice of a researcher is never a neutral choice but the product of a certain historical contexts and (2) if one chooses an issue such as the influence of mass media on people, aims should be considered; studying mass media for advertisement purposes is different from studying mass media to analyse and understand power relations that focused on racists, militarist and sexist contents.

1.1.4 The Academic Mind (1958)

The historical background of this study is McCarthyism. In the United States the “cold war” climate after the Second World War caused a fear of communism. Those who were accused of being communists – in cinema, as well as in the universities – could lose their job and be arrested. The term McCarthyism started to be used by the press in 1950 and referred to the fanatic activities during 1946 of Wisconsin Senator Joseph McCarthy. During the Truman presidency, in 1953 McCarthy accused defence secretary George Marshall, the architect of the Marshall plan and Nobel Peace Prize, of being a traitor and responsible for the spread of communism in China. During 1953, owing to his popularity, McCarthy became chairman of the Senate Committee on Government Operation, which controlled the Senate Permanent Subcommittee Investigation. During the Eisenhower presidency, this committee investigated communist influence in the “Voice of America” and also began an investigation on communist influence in the army, which ended up by considering Eisenhower himself as a threat. This obsession with communism which was supposed to have influenced the presidency also was considered excessive by the republicans and in 1954 a resolution emanated by Senator Ralph Flanders condemned Senator McCarthy. In this climate, in 1955 *The Academic Mind*, a research

coordinated by PFL and Wagner Thielens, could begin. Its aim was to study the consequences of McCarthyism in American Universities and it was financed by *The Fund for the Republic*, an emanation of the *Ford Foundation*, around which progressive intellectuals, such as John Kennedy, gathered. This research received a lot of funds – one quarter of a million dollars – and had the possibility of realizing an extremely complex sample made up of 2451 university teachers, of which 11% were females, from 165 university colleges. It employed two survey firms and a team coordinated by David Riesman to control and reflect on the whole experience (in Table 1.3 it is research type 1).

This research can be analysed from a methodological point of view following three directions: (1) the use of mathematical analysis and quantitative methods to give voice to charges against McCarthyism by university teachers; (2) the analysis of surveys by David Riesman, in which the complexity of the relation between the interviewer and the subject of the research emerges and (3) the lack of attention to gender relations, which leads PFL and Thielens to keep women and men interviewed in one single group.

The first point is interesting, because *The Academic Mind* is amongst the most elaborated studies by PFL from a mathematical point of view. It has two significant characteristics: (1) the progressive reduction of items from 21 to 4 to measure two main aspects of the “apprehension” indicator: “worry” due to attitudes and behaviours that could be criticized, and “caution” for avoiding attitudes and behaviours that could be criticized for fear of sanction and (2) the use of the analysis of the latent structure to verify the non-linear relation of the four items selected concerning latent dimension “apprehension”.

Such a use of mathematics and quantitative analysis, together with a neutral terminology (for example the term “permissive” instead of “liberal” or “progressive”, instead of “conservative”⁸) was part of a defensive strategy that under the “presence of objectivity” made possible to document in great details the violence of McCarthyism on American university teachers. In Chapter 2, qualitative answers given to several open items are elaborated and an accurate documentation of the violence of McCarthyism is negatively evaluated by the two authors (1958, p. 57):

In this period an individual could be called Communist for almost any kind of behaviour, or for holding almost any kind of attitudes. In them the world “Communist” became a vague and angry label, a “dirty name” with which an individual showed his disagreement with a teacher’s thinking. (...) Just as in the Salem of the 1690’s good citizens were quick to see in many an act an evil intent, and in each evil intent the signs of witchcraft, so in the post war decade many detected a lurking evil in the behaviour of college teachers which must surely spring from a subtle and pervasive Communism.

⁸PFL and Thielens (1958, p. 121) explain their choice as follows: “We have used the term permissive when often the reader, quite correctly, might prefer that we speak of liberal or progressive teachers. We have avoided these two words because they have changed their meaning too often in the great debate of the last decades.”

The Academic Mind marked PFL's return after market researches, to politically oriented researches similar to the one he carried out during his Viennese period. As David Riesman has noted (1979, p. 226):

Lazarsfeld used to remark that he undertook the Teacher Apprehension Study because it gave him a chance to put to work his passion for newly discovered contextual analysis. But, as a Marxist say, it was no accident that the subject was academic freedom: he cared about that. In the post McCarthy days it seems safe to say that he had a lifelong nostalgia for socialism Vienna style.

In 1957, McCarthy died of alcoholism at the young age of 49 for not being able to bear the burden of his failure and in 1958, *The Academic Mind* was published. At the time, the Republicans were still very powerful and of the six reviews to this study, five were totally negative because PFL had dared to openly criticize McCarthy. Nowadays, however, this publication is invaluable for having given a voice to the victims of McCarthyism and for all those who wish to reconstruct the reception of McCarthyism in American universities, as Ellen W. Schrecker, who has written the most complete study on this subject (1986), has rightly noted. *The Academic Mind* is also important for a discussion concerning methods, as the long article by David Riesman (1958) notes; here he clearly illustrates the "subjective" relation between respondents and interviewers:

an enormous variety of factors may serve to structure the expectations of both respondents and interviewers, and thus to influence what is deemed relevant- what is even conceived and thought- and what is heard and recorded.

Riesman shows that according to those who agree to paradigm of objectivity, the subjectivity that one thinks to have dispensed with by delegating the survey to a group of professional interviews is in actual fact only transferred from those who coordinate the research to the interviewers. One should also stress that the data on the sample of women interviewed has never been elaborated by Robert Smith, who shows a new way of elaborating data shown in *The Academic Mind*. This work demonstrates once again that a well-done research can always teach something.

1.1.5 Other Dimensions for the Classification of Sociological Researches

The three above-mentioned researches by PFL make it possible to integrate the six dimensions shown in Tables 1.1, 1.2 and 1.3: (a) *relations between women and men*: this can be included in the research; it can be excluded from the sample's choice; it can be excluded from the elaboration's choice; (b) *theory construction*: the theory can be constructed during the research (*Die Arbeitslosen von Marienthal, The Academic Mind*) or beforehand; in this case the research has the aim of verifying the theory (*Personal Influence*); (c) *individual and collective variables*: some researches consider both individual and collective variables (*Die Arbeitslosen von Marienthal, The Academic Mind*) and others in which almost exclusively individual variables are considered (*Personal Influence*); (d) *use of mathematics*: mathematics

may be used in more than one steps of the research (*The Academic Mind*, *Personal Influence*) or not used at all (*Die Arbeitslosen von Marienthal*); (e) *radical sociology's evaluation*: this evaluation considers the political impact of the research; this can be positive (*Die Arbeitslosen von Marienthal*, *The Academic Mind*) or negative (*Personal Influence*); (f) *key word* with which a research can be summarized: immersion (*Die Arbeitslosen von Marienthal*), verification of a theory (*Personal Influence*), accusation of the power (*The Academic Mind*).

The overall result is shown in Table 1.4.

Table 1.4 Characteristics of three researches coordinated by PFL

Dimensions	Die Arbeitslosen von Marienthal (1932)	Personal Influence (1955)	The Academic Mind (1958)
Explanatory/descriptive type	Explanatory	Explanatory	Explanatory
Antecedent/new Data	New	New	New
Quantitative/qualitative methods	Quantitative and qualitative methods	Survey for quantitative methods	Survey for quantitative and qualitative methods
Interaction with subjects	No interaction	Interaction with interview	Interaction with interview
Research sponsor	Using results	Using results	Not using results
Object of research	Towards bottom Type A	Towards bottom Type A	Towards top
Relation between women and men	Analysed	Not analysed for sample's choice	Not analysed for elaboration's choice
Theory's construction	During research	Before research	During research
Types of variables	Individual and collective variables	Individual variables	Individual and collective variables
Use of mathematics	No use	Utilization of models and indicators	Utilization of models and indicators
Radical sociology's evaluation	Positive	Negative	Positive
Key word of research	Immersion	Verification of a theory	Accusation of the power

1.2 Mathematics and Sociology from Statistical Models to Artificial Societies and Social Simulation

In this second part, the main changes in the relation between mathematics and sociology are considered after PFL. A first change has arrived from Lazarsfeld's statistical models and those published in the *Journal of Artificial Societies and*

Social Simulation. Furthermore, changes have occurred in mathematical structure of models also (due to increased possibilities offered by computer science) and in the research objectives (the passage from the paradigm of objectivity to the paradigm of action research/co-research and the paradigm of feminist methodology). The relation between mathematics and sociology ($S \rightarrow M \rightarrow S$) and ($M \rightarrow S \rightarrow M$) should therefore be evaluated taking into account what occurs before the actual research begins, that is to say researchers' stance and in particular their set of values as well as methodological and political choices.

The shift from Lazarsfeld's models to simulation models and to artificial neural networks has been described in various studies. These have focused not only on the results of these researches but also on the researchers that made such shift possible, portraying the complex relationships between university research centres and laboratories both in Europe and in the United States. The studies by Jeremy Bernstein (1978, 1982), Pamela McCorduck (1979), Andrei Hodges (1983), James Gleick (1987), Steve J. Heims (1991), Morris Mitchell Waldrop (1992), Albert-Laszlo Barabasi (2002) and Linton C. Freeman (2004) are very significant in that they reconstruct the synergies and contradictions that have led to such changes.

1.2.1 *The Paradigm of Action Research/Co-research*

The paradigm of *action research/co-research* differs not only from the one of objectivity, which, as we have seen, characterizes PFL's researches, but also from qualitative researches such as those that have a participant observer and that are in turn criticized by PFL. Researches that use this paradigm is aimed not only at finding out explanations but also at changing attitudes and behaviours concerning people or a specific situation. Kurt Lewin (1946 republished in 1948, pp. 143–149), who is the first to utilize the term “action research”, gives this definition:

action research [is] a comparative research on the conditions and effects of various form of social action and research leading to social action. Research that produces nothing but books will not suffice. This by no means implies that the research needed is in any respect less scientific or “lower” than what would be required for pure science in the field of social events (...) [action research use] a spiral of steps, each of which is composed of a circle of planning, action, and fact finding about result of action (...) Planning starts usually with something like a general idea. For one reason or another it seems desirable to reach a certain objective. Exactly how to circumscribe this objective, and how to reach it, is frequently not clear. The first step then is to examine the idea carefully on the light of the means available. (...) The next period is devoted to executing the first step of the overall plan. (...) The next step again is composed of a circle of planning, executing, and reconnaissance or fact finding for the purpose of evaluating the results of the second step, for preparing the rational basis for planning the third step, and for perhaps modifying again the overall plan.

The action research is different from PFL's researches in which actions happen after the publication of the research results; it is also different from researches that use participant observation. The “intimate familiarity” with the subjects of the research William Foote Whyte talked about had as its objective knowledge, and in

a similar fashion, Alfred Mc Clung Lee (1970, p. 7), the author of the introduction to the Reader entitled *The Participant Observer*, noted that:

Participant observation is only a gate to the intricacies of more adequate social knowledge. What happens when one enters that gate depends upon his abilities and interrelationships as an observer. He must be able to see, to listen, and to feel sensitivity to social interactions of which he becomes a part.

The objective of the *action research/co-research* is not only knowledge but also action, and it is precisely the intertwining between research and action that characterizes this kind of research.

PFL's researches and those based on participating observation are characterized by a [hypothesis→ fieldwork→ analysis→ conclusion] sequence, and differences are in the type of field work used. In the *action research/co-research* the sequence is more complex, as it is characterized by several research steps and actions: [Research (hypothesis→ fieldwork→ analysis)→ Action (action→ outcomes→ analysis) → New research (hypothesis→ fieldwork→ analysis)→ New action (action→ outcomes→ analysis) →]. This different type of research has a spiral process, which gets interrupted only when the actors of the research have achieved the changes desired. As Kurt Lewin has noted, "[action research use] a spiral of steps, each of which is composed of a circle of planning, action, and fact finding about result of action".

This type of research functions only if close collaboration between the different types of actors in the process of research and action takes place. The relationship between those who coordinate the research and the subjects of the research is therefore very different from those researches that follow the paradigm of objectivity, in which actors and subjects are kept apart. *Action research* is also very different from the "intimate familiarity" which is based on participating observation.

In *action research/co-research*, research is characterized by an explicit agreement among three different types of actors: (1) those who coordinate the research and the research team; (2) public or private actors, who take part in the process of changing and (3) the subjects of the research. Collaboration among these three types of actors who attempt to bring about changes of attitude and people's behaviour or a certain situation allows to (i) reach the necessary knowledge to formulate new theories and (ii) individuate the necessary action to produce change.

The refusal of the paradigm of objectivity does not mean that in this kind of research, objectivity is completely absent. Objectivity is in fact pursued through an ongoing reflection concerning the various steps of the research and all actors' behaviours and attitudes involved (including those of the co-ordinator). This is therefore a self-reflective research. Kurt Lewin analyses an example of research action based in Connecticut in which actors attempt to tackle racist behaviours. He describes the work of the observers that every day transcribe what happens in the different steps of the research in order to reach self-reflection:

The method of recording the essential events of who had attended the workshop included an evaluation session at the end of every day. Observers who had attended the various subgroup sessions reported (into a recording machine) the leadership pattern they have observed, the

progress or lack of progress in the development of the groups from a conglomeration of individuals to an integrated “we” and so on.

Remaining within the boundary of methodology, research methods change depending on the behaviour adopted by the action research and the choices of the various actors. Contrary to what happened in PFL’s researches, here no method of research is precluded.

The paradigm of the *action research/co-research* can be defined through the following points:

1. *Standpoint epistemology*. The objective of the research is changing the attitudes and behaviour of people or a particular situation.
2. *Methodology*. In order to reach this objective, the research is made up of the necessary action that brings about change. Such actions are determined by the analysis of the research activity (it is an action research). The explanations reached are considered valid if the answer (information) provided by the subject of the research is obtained, thanks to the collaboration of those who do the research and the other actors (it is a co-research). A higher objectivity can be obtained if during the research all the actions by the three kinds of actors (the co-ordinator of the research, other actors and the subjects of the research. It is a self-reflective research) are observed, transcribed and evaluated;
3. *Research methods*. All methods, both quantitative and qualitative, are possible, provided that these are in line with the above-mentioned methodology.

Action research/co-research began at the end of the 1960s and the early 1970s in the United States and Europe, following the encouragement provided by the example of students’ and workers’ movements. In the 1980s its popularity decreased, but nowadays it is widely used once again all over the world – from Latin America to Australia – because it has proved useful in several different and significant ways.

The main applications of *action research/co-research* are the following: (a) community actions, such as the research studied by Kurt Lewin concerning integration problems of minorities in certain communities; (b) children’s illiteracy and learning problems; for example the participatory action research coordinated by Paulo Freire to fight back illiteracy in Brazil, which provided the example for several action researches in education; (c) factory workers with problems connected with technological innovation and manager choices; for example the co-researches carried out in Italy and studied by Capecchi (2004); (d) groups affected by psychical problems, disabilities and old age; for example, David Epston’s co-research (1999) to help people with mental problems in which a “coproduction of knowledge by sufferers and therapists” was realized; (e) interventions to help people at risk: those who have justice problems, drug addicts, etc; for example the “Sonda Project” directed by Massimo Buscema exposed in the third part of this historical introduction; (f) organization of strategies for local development in which more actors aim at tackling an economic precarious situation; for example the researches in Norway, Sweden and Denmark described by Lauge Baungaard Rasmussen (2004).