# Evolutionary reading of a pedagogic experience with a course of statistics for social sciences

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**Abstract**

How can one make sure that the evolutionary theory of the origin of life is false if one is not acquainted with a true and natural evolutionary process? It happens that, with the appropriate insight, evolution can be found everywhere as in nature as in our lives. So, one is always plenty of real evolutionary processes to compare with the alleged evolutionary process that according to the evolutionary theory gave rise to species. To illustrate how evolution is seen in a concrete, not obvious situation, a running pedagogic experience with a course of statistics for social sciences is read in evolutionary terms. A very simple procedure for management results. It consists in two steps: enabling and selection. More explicitly, one must furnish an environment in which the desired output may appear most surely in rudimentary form -this is enabling. After that, perfection must be step by step constructed thanks to preferential rewarding of those products that represent an improvement over their predecessors and companions -this is selection. Contrary to what one may expect, the power and value of the human factor is naturally exalted. Complying with a universal prediction of evolution, virtues and utter pitfalls coexist shoulder to shoulder all along our evolutionary process. But in nature only perfection is observed as in extant populations as in the fossil record. For this reason, the Darwinian evolutionary theory of the origin of life and all Lamarckian variants are obviously false.

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# 1 Introduction

The scientific evidence in favor of the evolutionary theory of the origin of species is overwhelming, from anatomy to molecular biology, from paleontology to ecology, from system theory to genetic programming (UCMP, [1], 2012). As a consequence, every person that considers himself or herself intelligent accepts that theory as the explanation of his or her existence.

Anymore: the evolutionary theory of the origin of species is obviously false.

In fact, a person that accepts the evolutionary theory because it is supported by too many evidences but without looking at its obvious falsification is like a child that accepts to go with a professional kidnapper that resembles the true father with respect to dress, face and voice but with an obviously different smile.

But, what to do when the kidnapper is all the child knows? This is exactly what happens to many persons that were taught since childhood that the human race arouse by evolution and that the chimp and the human have a common ancestor. What to do when the kidnapper has resulted to be a very good father that has responded for almost all needs of the child? Actually, many people earn a life thanks to evolution and honestly love it. We must recognize that we

have here a very difficult case but we do know that every child is eager to know who his real father is. So, our duty is to show things clearly and sharply.

Experts enjoy now abundant material to judge by themselves (Rodríguez [2], 2010):

1. The genome is software, i.e., the genome contains verbal instructions to synthesize the continuation of life.

2. Evolution is indeed a property of life and as such it is a software developer by means of blind changes that are reproduced if by mere randomness these are found to help surviving in a given milieu.

3. The evolutionary theory of the origin of species is that biological evolution is the software developer that is responsible of our existence and of that of most species.

4. To decide whether or not the evolutionary theory is correct, we must test whether or not the supposed evolutionary process postulated by the evolutionary theory fulfills the elementary laws of software development. In that regard, humans beings are very clever for software development and moreover we can simulate it by means of evolution with Java. This very rich joint experience allows us to firmly declare that there is no software development without bugs whose correction generates more bugs. For biological evolution this would correspond to a mandatory prediction of infinitely many cases of malformation and malfunction all along the evolutionary process. Nothing like that is found neither in extant populations nor in the fossil record.

5. The conclusion is clear: biological evolution is not and cannot be the cause of our existence.

The problem with the aforementioned explanation is that lay people must believe it by faith. Fortunately, ordinary life is a great source of real and true evolutionary processes, so both experts and lay people have plenty of raw material that they could judge by themselves. This can be pursued to the last consequence, even to a genetic description in terms of genes, chromosomes and all that (Rodríguez [3], 2011b).

With some training, one can see evolution everywhere in our ordinary lives. To illustrate how this is done, we present here an evolutionary reading of a pedagogic experience with a course of statistics for social sciences. All this implies that we are plenty of real and true evolutionary processes and so we can confidently compare real and genuine evolution with the supposed evolutionary process that according to the Darwinian evolutionary theory gave rise to the origin of species. After that, we can easily decide that the evolutionary theory of the origin of life is obviously false because it does not obey a simple and mandatory law for every evolutionary process: real and true evolution is always plagued with huge amounts of imperfections whose traces are not observed neither in the fossil record nor in extant populations in spite of the fact that they all point to extreme complexity.

## 1.1 The idea and implementation of evolution

We contend that ordinary life furnishes every human being with an immense evolutionary lab. In fact, biological evolution can be considered as a fully automatic implementation of an idea that is immanent to every human being. As such, it has been glorified by every human culture, each one with its own many versions as the following:

**The way to wisdom:**

1. Principle of humility: do not think that the ideas that firstly arrive into the mind conform the best solution to your problem. Instead, open your mind to enlarge creativity, to enrich your options and to conceive variants.
2. Principle of strong humility: after having doing your best, do not think that your ideas conform the optimal solution to your problem. Instead, be ready to welcome very strong attacks. Or, if you fear them, ask for advice but test hearts.
3. Make of these two principles of humility a way of life.

We all know that this commandment functions. Such a certainty surely is footed on a simple mechanistic formula that, if applied, will lead you to success more than to failure. An immediate proposal could be as follows:

**Receipt of the round table:**

- Before taking a decision, assess as many variants as possible.
- Remember that slight modifications can sometimes create miracles.
- To enlarge the number and quality of options, welcome every advice and more to the point, ask for it.
- Make all this recurrently.

One more step in mechanization would read as follows:

**Procedure of evolution:**

1. Create variability: blindly and purposelessly make changes and recombination of ideas to produce new ones.
2. Assess ideas and choose the best.
3. Make this recurrently, over and over.

Because we have too much experience in applying all these receipts and are at the same time extremely intelligent, we can understand and accept them without troubles. But, what happens when such a great intelligence and experience is lacked? In that regard, the next claim is astonishing:

**The reality of biological evolution: the way to wisdom, the receipt of the round table and the procedure of evolution can all be successfully and fully implemented with atoms and molecules as it is shown by life on Earth.**

In fact, life on Earth includes evolution as a fundamental property. Some details are the following:

1. Surviving is the one and only task of every subject involved in the game of life.
2. The source of variability is provided by the various mechanisms that produce mutations.
3. Recombination -the equivalent of asking for advice- is made by the recombinant machinery.
4. Selection -natural or artificial- corresponds to the process of assessing ideas. It is evidenced by the fact that the carriers of some genes consistently left more offspring than others.
5. Recurrence arises from the reproductive capability that offspring has and so the cycle 1-2-3-4 is repeated over and over.
6. The net result is that some genes tend to multiply while relative frequencies of others fade away. At the same time, some characteristics tend to get perfect, well adapted to the milieu and co-adapted with other characteristics.

Molecular biology (Doe [4], 1992; López [5], 2008; ) is before everything else a song of praise that exalts the incredible grandiosity of the implementation with RNA and DNA of the principle of evolution. Given such a great power, many people consider the following theory as a simple corollary:

**The Darwinian Evolutionary Theory of the Origin of Species: biological evolution, which is a crude reality, is the sufficient and natural explanation of the origin of all species.**

There are many, many facts that back the evolutionary theory. Just think of the incredible resemblance of the ape with us. For instance, a male gorilla can tenderly take in within its fingers the jaw of a baby, just as we do with our children to transmit confidence. By the same token, the anatomy of a dog, a horse, a pig are all quite similar to us. Even fishes are like us: when a male defends its territory and female, it uses against competitors a voicing that is identified by every human being as menacing by contrast to that directed to its female, which is identified as a tender invitation to feel right and loved. And if we look to bees, their honey is extremely good as for us as for them and is also good for bacteria if sufficiently dissolved -in natural concentration and purity it is antibacterial.

In spite of the great scientific support given to the Darwinian evolutionary theory, objections always have existed, say, evolution is a self-killing process (Criswell [6], 2004), a proposition that can be easily verified for human languages: mutations in tandem rapidly end in nonsense (Rodríguez [7], (2009d)). Of course, corrections are not difficult to imagine. One very ancient and very strong is the following (Rodríguez [8], (2011a)):

**The Lamarckian Evolutionary Theory of the Origin of Species: the Darwinian biological evolution is insufficient to explain the origin of all species but not if it is suitably helped from outside.**

In spite of the fact that the concrete helping mechanisms presented by Lamarck were found to be false, the way of using evolution as a modern and ordinary tool to solve problems is by helping it with suitably accelerating trickery.

The enormous freedom that the Lamarckian Evolutionary Theory contains may produce the impression that it cannot be refuted at all. Nevertheless, the life we know is extremely complex and, so, people are found that might claim that evolution, in any of its versions, cannot explain life (Rodríguez, [9] 2009a) and so they invent a god-creator or accept one of a given religion (Rodríguez, [10] 2009b). Example:

**The Creationism of the Christian monk Mendel: powerful as the Darwinian and Lamarckian evolutions could be, neither can explain the origin of most species, man included. From God we come directly and to God we return back to be judged.**

Mutatis mutandis, all versions of evolution or creationism, of which there are many, many, many, can be accommodated as one of these three that we have presented.

*Our strategy to decide these insights is the following:*

1. *Study real evolutionary processes to see how they behave.*
2. *Formulate laws that every evolutionary process must comply with.*
3. *Next, use those laws to decide how much truth there is in evolutionary theories.*
4. *Creationism becomes interesting for us in the only case in which evolution results to be false. The problem is that the evidence in favor of evolution is overwhelming and so its rejection in favor of creationism must necessarily say something about the nature of the Creator (Rodríguez [11], 2009c).*

Our immediate task is henceforth to exhibit true and real evolutionary processes to see how they function.

## 1.2 Evolution everywhere

One can see evolution -true and real- everywhere. In fact, one can unveil an evolutionary process everywhere and every now that one is trying to use wisdom to solve a problem. The reason is that solving a problem consists in listing all possible solutions that come to the mind, to ask friends for more options, to assess solutions to choose the best and to see how things function, to next begin the whole process anew by making changes and recombination of ideas. In this process, some elementary ideas are rewarded with its continued existence in the list of preferred options while others are chastised with disappearance and oblivion.

## 1.3 The signature of evolution

Now that we have evolution everywhere and that our personal lives are immersed in evolution, we must ask ourselves: Which are the laws that must be fulfilled by every evolutionary process?

Since we have equated evolution and wisdom, the fundamental laws of evolution and wisdom coincide. So, what is the fundamental law of wisdom? The answer is immediate and is well known to everybody:

**The fundamental law of wisdom is that wisdom is vanity, wind and sand.**

Proof: the glory of every success lasts until one gets open to own and foreign criticisms that sometimes come for free and without delay. And if you aim at something better, you will suffer so much that walking under a sand storm will be easier. But if you got exactly what you aimed at, very soon your soul will lost interest and you will repeat the words of the Preacher: vanity of vanities, everything is vanity.

At the heart of this failure we find something that is ubiquitous and more powerful than wisdom. It is complexity, whose operational description is as follows: mediocre solutions can be easily found but cannot be connected with current and possible insufficient perfection if not through many intermediate stages that cause long and exacerbating stagnation.

This is a generalization built on the experience of every human being and amounts to a mandatory prediction for all evolutionary processes, be they Darwinian or Lamarckian:

1. Complexity means that too many and intertwined constraints much be fulfilled.
2. Complexity, has no limits because more conditions always can be added to those already present.
3. By contrast, evolution is very limited due to the fact that it is real.
4. The net result of the evolution vs. complexity struggle is that evolution will not progress without leaving behind a very rich spectrum of imperfections.

We can say in short:

***The signature of evolution is: imperfection is ensued by imperfection while tears fall all around.***

Now, the Darwinian Evolutionary Theory of the Origin of Species is the central axis of modern science. There are too many evidences in favor of this theory and they are overwhelming. So, it will marvelous that in a near future we could have a robust proof, one that eventually could be acceptable for future generations, that two specific species are joined by evolution. Sibling species of insects seem to be a very good candidate (Olson [12], 2004). But, beware, the evolutionary theory is not that two or three species are related by evolution but that biological evolution is the explanation of the existence of every species, man included. This theory is obviously false because it cannot show in the form of imperfections the deep scars of evolution that the battle against complexity should had left on it. Quite to the contrary:

- If you say that your ancestor is a chimp, or a dog, or a cat or a mouse or whatever, you must recognize that they are all perfect. For instance, in spite of the tremendous persecution by cats, mouses not only continue to exist but abound everywhere.
- If you declare that your ancestors died long ago and that they exist only as fossils, on examining them you will arrive to the very same conclusion: they are all perfect. Example: the very fact that we have fossils of giant dinosaurs that ceased to exist some 80 million years ago shows us that the terrible mechanical problem of making moving monsters was resolved with excellence.
- To grasp what imperfection is, please, visit hospitals and keep in mind that every disease can be genetically mimicked. Consider, for instance, a person that has a blurring vision. This can be an illness associated with aging else the product of a genetic defect for the visual system, say, in the gene encoding for collagen (that helps given structure to the vitreous humour, the gelatin inside the eye).
- Summing up: the Darwinian evolutionary theory depicted by modern science or by its Lamarckian variants are all a contradiction: they amount to evolution (one species coming from another) without evolution (no trace of a battle against complexity).

## 1.4 Our purpose

Being aware of the terrible importance of out theme, we underscore that our key point is that we have plenty of true and real evolutionary processes, so that we can contrast the evolutionary theory with reality. But this means to make an effort to see evolution everywhere. Indeed, many diverse evolutionary processes may be associated to any given problem in real life.

To show a non trivial example that illustrates how evolution is unveiled in real life, we make here an evolutionary account of a pedagogic experience with a course of statistics for social sciences that includes design and administration.

Our aim will not to pursue a complete specification of the evolutionary processes behind our problems but rather we look after direct applications. We find, in particular, how nice, simple and powerful are our administrative principles if they are formulated along an evolutionary perspective. Besides, we will not forget our priority: to see in which form recurrent imperfection -the signature of evolution- is inbuilt in our experience.

# 2 Competence among world views in pedagogy

We describe firstly the world view that illuminated our early pedagogical work to consider next whether evolution could classify as our current world view.

## 2.1 The axiomatic methodology as a false start

The mathematical education that the Author received stressed clear reasoning and clean deductions. Let us refer to this insight as the **axiomatic methodology**. Most persons that fall in love with mathematics also fall in love with it. This is done instinctively and eventually can be developed into a passion. The axiomatic methodology might be elected in this way as a world view, as the light and law to regulate the building of knowledge and the generation of practice. Precisely, such was the case of David Hilbert, who formally proposed the now called Hilbert's program (Zach [13], 2009), which pursued two aims:

First, a formalization of all of mathematics in axiomatic form and second, a proof that this axiomatization of mathematics is consistent. Hilbert was delicate enough to recognize that geniuses may need no proofs at all because they rely on their powerful intuition, so he specified that proofs must be exhaustively stated and of course shall be conclusive or, more precisely, proofs must be reproducible by some algorithmic procedure in a finite number of steps. Thanks to the great effort made by Hilbert and by his contemporaries to investigate the issue, it was discovered that the Hilbert's program was a false illusion such as it was proved by Kurt Gödel in his two theorems. The first argues that consistent systems (clean of contradictions) are in general incomplete (cannot enclose all true propositions). The second theorem denies the general possibility of deciding in within the theory whether or not there is no contradiction in a set of axioms.

Now, we may look at all this as an accurate and rigorous study of model problems that reflect those that we face in our ordinary life. This is exemplified with the following question: why does the Lord allow so much badness in this world given that He is good? This consideration together with more mundane ones unveil the fact that a human language is in general pray of inconsistency every time a complete description of a sufficiently complex object is looked for (Myers [14], 2009).

Thus, we arrive to the next conclusion: the axiomatic methodology is made of too weak a raw material that is unable to sustain itself so, it breaks down.

But, can we recycle the debris that remained after the collapse of the axiomatic methodology? And more to the point, what are the implications for pedagogy? These and related questions have proven to be exquisitely complex.

The first important implication is that it is unethical to convert the axiomatic methodology into a religion and to demand from everyone to understand and learn to concoct proofs for every proposition and to make of proofs the core of every course in Mathematics. Devising axioms to study their predictions by means of rigorous proofs is very important and has a honorable place in our culture and a preferential place in pure mathematics but cannot be preached as the purpose of life of every person or of the university.

A second implication is that one must expect from every consistent theory about a complex system to break down rather soon than later. Therefore, trust not theories, instead listen to nature, to experiment and to your intuition (Rabinowitz [15], 2001).

The classical example that illustrates this is special relativity: every one thinks by instinct that if your velocity with respect to the train is 5 Km/h, and if that of the train with respect to the ground is 55km/h, then your velocity with respect to the ground will be 60km/h. So, it was a nightmare when it was discovered that the velocity of light is constant irrespective of the frame from which the source of light is observed. The implications of this fact were consigned in the theory of special relativity and then it became intriguing to explain why. The explanation was achieved by reducing it to the theory of groups, which are sets with a generalized sum (Rodríguez [28], 2008).

Turning to pedagogy, one might find that what has functioned in the past may malfunction in the instant to come. So, be open minded to ideas, to experiment and prepare yourself to take decisions on the fly. More to the point, propitiate the expression of dissatisfaction and adopt negotiations as a way of life.

Another great implication stems from a simple observation: we, human beings, exist and have survived and progressed (at least technically) in spite of the fact that our language is inconsistent and our usual mathematics are incomplete. While things are not as clear as one would like (Collins [17], 2001), we can readily express some ideas on how this has been possible:

We observe the world and pay attention to those things or processes that affect us. Next we try to capture that part of the word that most affects us in mathematical models that are consistent but that have very partial validation. It happens that diverse models compete for fairness, completeness and computability. The result is a bundle of mutually contradictory models that having partial validation enjoy sufficiently large range of covering to represent powerful tools for design and decision making. At a large scale, this says that we have different sciences, say, cosmology, planet science, Earth sciences, ecology, biology, molecular biology, quantum mechanics, field theories. At a lower scale, we see that every specialist always has ideas on his or her own that allow him or her to survive in the deal. In short, compartmentalization of knowledge into desirably maximally consistent but incomplete domains is the key of our modern culture. We rely on experience to decide which model to follow on which occasion.

## 2.2 The truncated axiomatic methodology

In spite of the incompleteness of mathematics, the art of proofs is so nice and captivating that the Author used to think that it is at the very heart of mathematics. In consequence, a primordial duty of a teacher of mathematics would be to teach this fine and delicate art to students. So, he used to overload his students of science with proofs, which were sometimes appreciated by them. All that was very difficult as for the teacher as for students. The prior formation of students that were incorrectly taught and that were wounded with fear and hate against mathematics was blamed as the culprit of this generalized failure.

The overall conclusion is that a truncated version of the axiomatic methodology was still powerful to orient practice but with disappointing results. Things are analogous to a recently dead scorpion whose tail conserves the power to sting and cause damage. But exactly, what do proofs have that serve more as a poison than as a light? Proofs are very difficult, in general, but if a teacher understands what he or she wants to prove, then he or she can explain the whole mater on intuitive grounds and for students of science this may suffice while everything else becomes an unnecessary overburdening load.

The generalized and recurrent failure with the axiomatic methodology incited the Author to revise his blind appreciation of that methodology and to search for a more balanced and righteous pedagogical insight that was needed in his work with lay students.

In the evolutionary jargon, we can say that the axiomatic methodology as a world view for pedagogy perished because of a lack of adequacy. We get, therefore, expectant to see what comes to fill in the created vacuum.

## 2.3 Evolution as a candidate for a winning world view

If the so much beloved axiomatic paradigm, whole or truncated, is rejected as a desirable single unifying world view, the best option is to mix different visions. Thus, we concede a victory to complexity and recur to a healing patchwork. Nevertheless, we find that the role of evolutionary principles is apparent and pervading. To begin with, the university where this work is done demands for imparted education extremely high fees from which its surviving depends. Because evolution is all about surviving, that is why evolutionary principles might eventually serve as the natural all encompassing frame of our project. Are we saying with this that evolution can be declared as the winning world vision whose power goes beyond Gödel's theorems?

No, that is not the case: Darwinian evolution deals with adaptation of the fittest but not with the problem of how to fabricate fitness efficiently, at the required tempo. Nevertheless, if one injects possible winners that were devised following external principles, then evolution can be strongly accelerated (this is our interpretation of the ideas of Lamarck). As it is explained below, system theory and human psychology were employed as very powerful oracles (sources of free knowledge). So, Lamarkism seems to be a strong candidate for being a winning world vision. Let us keep an eye on this possibility to see how well it does. Thus, it seems extremely rational to consider that the surviving of the university hangs on money defrayed because of matriculations and that, therefore, our first duty is to respond satisfactorily to the clients that pay, i.e.,

to parents. Besides, we have other clients: students and the Department of Mathematics that also represents the university.

# 3 General client requirements

We associate clients and requirements in a form that produces the highest independence. This is done as follows:

## 3.1 Fathers

Parents desire their offspring to get well prepared. A good content of the course must be offered to satisfy fathers (see below). The material that shall be learned is given beforehand both in the form of a free pdf file (Rodríguez [18], 2012) and as a printed book that every student must buy on a modest price and that is intended to be covered during a semester.

## 3.2 Students

The course of statistics for social sciences is offered by the Department of Mathematics. No prerequisite is needed, so students take the course in the first semester but many retire and other lose it, so we have people that repeat it maybe as the final course in their careers.

Students come from diverse departments: from law (60%), political science (12%), architecture, design and arts (13%), anthropology (5%), history (4%), languages (3%), psychology and philosophy. These students take this course because it is the best option for their careers given the faculty directive that every university student must know some mathematics.

Marks are a matter of surviving: they automatically decide whether or not the student must continue in the university. This is another fold that is naturally associated with evolution. So, (Lamarckian) evolution gains another point as a world view. Since surviving is important for students, it seems rational to assume that students desire good and even perfect grades, which range in within 0 and 5. At the same time, students also desire to be well prepared but the resultant load shall be prudently administrated so that the created tension could be constructive. In our case, we increased step by step the volume of the dictated material until both our own demands and those of the Department of Mathematics were fulfilled. The resultant load seems to be high enough to be challenging for everybody but not too high to get dangerous for most persons.

## 3.3 The Department of Mathematics

Together with fathers and students, the next important source of constraints is the Department of Mathematics in regard with the content of the course (discussed below) and examinations.

The are 4 partial examinations, each one counts 15% of the total grade, plus one final examination, 25%. Daily work has a total value of 10%. Students must

compose a project in which they invent and solve problems that must be applied to their careers, 5%. Partial examinations are devised by the teacher but he does not participate in the design of the final one, which can be considered as the judge of the performance of both students and teacher.

# 4 Our course of statistics

We will consider now the aim, structure and contents of the course, our management directives and their implementation. We end with a report of results.

## 4.1 Aim and structure of the course

Many students take the course as the only one in this area in all their career. So, we faced long ago at the level of Department the dilemma of pursuing statistics directly else to offer an introductory course with good fundamentals of probability and almost nothing else. The problem is similar to that of building the basis of house and to stop there else to make walls and roof but without bases. As we see, the dilemma is a terrible one. For someone that is a defender of the axiomatic methodology the expected decision is to build good basis. Nevertheless, we considered that this option was more appropriate for a course with two semesters but, in our case, a course with more content of statistics and less of probability would do it.

Now, statistics is *the mathematics of the collection, organization, and interpretation of numerical data, especially the analysis of population characteristics by inference from sampling* (The Free Online Dictionary [19], 2012).

Statistics as a part of mathematics is fully implemented according to the axiomatic methodology. It is built over measure and probability theory and includes also multivariate calculus both in real and complex variables. So, it is very complex: not in vain, teaching statistics to students of science trying to cope with the axiomatic methodology is a torture both for the teacher and for students. In fact, the Author has survived two plain rebellions, one from students of biological sciences and another from students of social sciences. And other colleagues have passed over similar events. So, we are compelled to ask ourselves: is there a solution or an alternative approach? Yes. Let us see it.

From the stand of organization, the axiomatic methodology offers a bottom-up approach. This is suitable for a course of statistics for mathematicians. But our course is one of statistics for sciences. Now, science is an idealistic program that tries to fit reality with models. So, by its very nature, science corresponds to a top-down approach which gives to the scientific program the status of a great design, in which statistics is constitutively important but anyway second ranked. From a scientific perspective we can define *statistics as the science of taking decisions about beliefs given that we have information on random samples.* Statistics significantly lowers the cost of decision making but at the price of committing errors. Statistics helps when the cost of damages caused by errors are definitely less than the price of getting perfect information.

In spite of its imperfection, statistics is widely used in decision making due to the rich representation of distributions of central tendency (with its only bulk

around the mean value) that can be idealized or fitted by a normal distribution whose density function is a Gauss Bell. This is the easy case that we consider in our introductory course. Other cases are dealt with in nonparametric statistics (Rodríguez [20], 2010) and by simulations (Rodríguez [21], 2011c).

The decisions we face in regard with distributions of central tendency are of the following type: Are a given datum and the bulk of the distribution both explained by the default mechanism? The accepted protocol to answer is: an event that is in the bulk of the distribution is explained by the default mechanism while outliers (those that reside in the far reaches of the distribution and far away from the mean) are not. Example: in certain human population the mean height of males is 170cm and the standard deviation is 10cm. If no additional information is furnished, John is normal because his height is 180, almost the average value. It is usually accepted that a normal value corresponds with a healthy person in regard with growth factors. But Peter is abnormal because his height is 2.34, a datum that is farther than 5 standard deviations: he is invited to a medical revision to see whether or not he suffers, say, a hormonal malfunction.

Hypothesis testing is in the top if one follows the axiomatic methodology. By contrast, it is the very face of the scientific method. Let us notice now that this method is immanent to every human being because it is biology given as an everyday tool. Example: babies rapidly acquire habits in regard with sleep and feeding routines and express discomfort if these are violated and distress if broken. Or consider a five year old boy that expressed himself about his newborn sister: *"she has no pennis and she sleeps during daylight"*. We see that he has inbuilt the decision machinery needed to make scientific inferences that we formalize in contingency tables.

`Now, we have decided to accept the challenge given by biology: if the scientific method is inborn as a tool of very common usage, can somebody nourish it that it becomes strong amidst a joyful and constructive experience?`

We highlight now that mathematics and its axiomatic methodology has proven to be very important in science because an immanent part of science is to test theories. These are compound of a set of axioms and suitable predictions, which are preferentially calculated with the help of mathematics. Our immediate problem is the following: how can we dispense higher mathematics given that they are so fundamental in science?

In short, our procedure is analogous to what nature does with us: we can infer correct answers by instinct although we do not know what our brain does. In the same way, we hide from students specific calculations - that cannot be done without higher mathematics- but we show how the structure of knowledge is built. A concrete example about the z-table helps us to see what this means:

Along the axiomatic methodology, the z-table results from the possibility to make a change of variables in the probability density function of the Gauss-bell: anyone such function can be transformed into the density function of standardized normal distribution with mean zero and standard deviation one. Now, one must calculate its definite integral for sufficiently many values by

numerical trickery. So this is done once in the whole life and results are consigned in a table.

Let us see now how the top-down approach is implemented to introduce the z-table. First, we see the binomial distribution and we verify that the probability over all events adds up to one. Next, we introduce the Gauss bell as the continuous idealization of the bar diagram of the binomial distribution. Everyone readily accepts that the area under the bell is one.

Most people readily accept the interpretation of an area under the Gauss bell as a probability, and that one can approximately assess its value by looking at the corresponding drawing. This means that the area does not depend directly on the mean or dispersion but on the relation of the area to the overall bell. With this we "prove" the theorem of the change of variables but, of course, we never mention that. Once this is done, we have an expedite path towards the standard normal distribution with mean zero and deviation one: all we need to calculate $p(a < X < b)$ is to draw another bell, of equal shape, but in a parallel world in which units are different: the mean is zero and the deviation is one. We left after that to mathematicians the work of calculating areas and their work is consigned in a Z-table.

### 4.1.1 The top-down vs bottom-up struggle

From the stand of complexity theory, we see that our top-down approach diminishes the complexity of problems because we use ordinary experience or common sense as an oracle that solves or helps solving problems without charging the user. We have here another point in favor of Lamarckism as a possible world view. Nevertheless, this looks humiliating because Lamarckism results to be an explanation of everything if only other agents exist that previously have suffered to solve problems. Example:

We include here (see below) a very simple and powerful evolutionary receipt for management: enabling and selection. This procedure fairly conforms to evolution, looks very simple, very powerful and very appropriate for everybody. It is marvelous. But it was discovered by the Author on reflecting not on evolution but after thinking about the vision of the ancient writers that composed the Genesis of the Bible: God decided to populate the Earth with human beings, and what did he do? He showed us a masterpiece in self-organization: He created just a male-female couple and ordered them to reproduce. The interesting thing is that no ones recognizes that command but everybody obeys it. Why? Because everyone is enslaved to a coercing sexual instinct that is supported with an incredibly powerful biological infrastructure that enables as the instinct as reproduction itself. And, finally, do you know why you enjoy to travel so much?

Does the lack of creativity of Lamarckism mean that the bottom-up approach of the axiomatic methodology is the only ethically allowed? It happens that things are more complex than envisaged by this question:

The crude reality is that we, human beings, are biologically programmed to exercise the scientific method in its full glory, something that includes the possibility to develop highly sophisticated mathematical deductions to calculate null hypotheses. Thus, the top-down approach is complete precisely because the bottom-up approach complements it.

Nevertheless, if one follows many mathematical texts, that may deal with

a concrete scientific theme, one would conclude that everything seems to go bottom-up and that, therefore, the top-down approach is a redundant. We know now that this is false:

One has no power to calculate all true propositions related to complex natural objects, such as predicted by Gödel. Therefore, incalculable emergent-properties appear that must be read and studied directly from nature and from above -and that is why a top-down approach is inevitable to any acquisition of knowledge about complex systems. Nevertheless, once we get acquainted with such emergent properties, one may try to reduce them somehow, i.e., to deduce them using the axiomatic methodology but with schemes that include contradictions and/or infinites. As to concrete examples, let us offer various candidates:

1. By reading the creationist Lao-tzu [22] (2500BP), one may arrive to the conclusion that the most important things for a human being -inner joy and peace- are all surrounded by inconsistent verbalizations. So, how can you know that you are correct in choosing certain behavior? By looking directly over your own consciousness -if only you have the courage to decide that it exists because in the light of scientific research doubts may appear (Chakraborty, [24] 2012).

2. We all have seen how boiling water becomes gas, a phenomenon that is known as a phase transition. It happens that the mathematics that try to follow it deals with infinites, whose treatment must render finite and observable results (Nishimori and Ortiz [25], 2010). The only justification of all that trickery with infinities is that it functions.

3. According to field theories, behind our material universe there is a huge and turbulent world of quantum fluctuations from which our world derives its properties. But the corresponding calculations deal with infinities that when subtracted from other infinities render finite results that coincide with observation. Why this functions is partially explained in terms of cooperative behavior, the very same explanation of phase transitions (Delamotte [26], 2002).

4. A key point in theoretical evolution is differential surviving in response to the challenges given by the milieu. This is called selection. Mathematical models depicts it as a systematic effect without variance and these models predict what we want to hear: that the fit survives and fill the Earth (Logan [27], 2009)). So everyone tends to think that this concept is simple and well understood. Maybe that is so but the Author is not sure. The Author rather sees in natural selection an idea that is imposed over biology and that results to be fruitful. But it is another matter to explain how selection arises directly from nature, from differential surviving, and which are its natural characteristics. Thinking of that, it is not excluded that

the concept of selection may arise as a limit averaging value taken over infinitely many evolutionary processes. It seems that the mathematical quasi-formalism of Feynman Integrals (Rodríguez [28], 2008 l.c., chapter 4) is appropriate to discuss this idea.

5. Human beings like to say: *"I believe that"* or *"I don't believe that"*. One such a confession seems to result from a direct reading of consciousness and so one has no clear idea of where it results from. It is not excluded that the neural machine responsible for the synthesis of beliefs may be rather simple. But at the same time, some beliefs seem so abstract and so powerful, like the faith in God else in evolution, that one may suspect that they are sustained by extremely complex neural operations that serve as envelop to infinitely many neural events that make of consciousness a fertile terrain for the gestation of contradictions. This helps to understand why no proof is convincing for everybody: in science all alleged proofs are proofs module the given axiomatic system and are accepted in a certain social circle but not everywhere. In regard with us, we see that every human being is a fabric of beliefs, truths and dogmas and that without them humanness cannot be imagined. So, we cultivate in our community a deep respect for the beliefs of every person. That is why we teach to use Java to clarify and enrich thoughts but at the same time we recognize that beliefs are not enslaved to the logic of the scientific thought. Say, there exist beliefs that are resistant to sharp and clear cut falsifications and so they are strong against every evidence to the contrary. That is why we say that at the bottom of every belief one finds irrationality (Rodríguez [29], 2007).

### 4.1.2 Anti-dogmatic education

The goal of our course was not just to teach the know-how of the modern scientific method but also to show over direct experience that science is a handcraft, a hand made product made by humans using a methodology that is borrowed from biology: for a distribution of central tendency we define extreme events as those that are in the tails of the distributions, far away form the mean. Next we notice that extreme events usually elect new explanatory mechanisms apart from that that explains the bulk of the distribution. In the next step we formalize this situation as a protocol for the formulation and rejection of null hypotheses. We see how the whole protocol functions over the binomial distribution to exhaustively showing by example how the scientific protocol is build and implemented... as a handmade product.

We expect that a person that is educated in our style is more creative and critic of scientific propositions than other that does not know that science is a handcraft product and instead thinks that it is the cultural equivalent of being God-given.

## 4.2 Contents of the course

The purpose of our course is to teach the fundamentals of the scientific method using a top-down approach but showing constructively how the main building blocks are concatenated. Now, the most elementary description of the scientific

method is as follows: observation, fabrication of theoretical models, contrast between prediction and observation, acceptance of rejection or proposed models.

So, the content of the course was an implementation of the scientific method as follows: in first place we have descriptive statistics that represents observation. In second place we introduce probability as the natural frame for problems for which we only have knowledge about a random sample. We work out completely the binomial distribution for simple cases and next we learn to calculate it mechanistically in the general case. This distribution is idealized by the normal distribution. We learn the protocol of hypothesis testing over the binomial and normal distributions. This is made as an abstraction of our usual way of taking decisions in the presence of random perturbations.

Once the protocol for hypothesis testing is learned, we pass to a mechanization under a very general setting: **the scientific method is in principle a contrast between what one sees and what one thinks or expects.** This description of science unifies all applications of statistics to the scientific method. It is introduced in two steps. In the first one, some key cases are studied in which equality of, say, means, is tested, and then a dictionary of experiments with 10 cases is dealt with in a more general way. These cases comprises one or two means and variances and proportions. We end with $r \times c$ tables and a test for homogeneity of multiple proportions.

## 4.3 The syllabus

Experience shows that 3 problems per day represents an appropriate doses of work for the students and moreover suffices to cover all the proposed material. Nevertheless, there are some few days in which 2 difficult problems are demanded or perhaps 4 or 5 easy ones.

## 4.4 Self-teaching as our methodology

Mathematicians are in generally proud of teaching and in consequence dedicate a substantial proportion of available time to teach. Nevertheless, we have opted for another methodology: our students are autodidacts and the role of the teacher is just to serve as a tool for feedback. Our reasons are as follows.

1. Learning is a strictly personal affair and teaching is just an illusion. This implies that teaching resources must not be addressed to facilitate teaching by the teacher but self-teaching by students.

2. Self-teaching is full of hard challenges. Therefore, one must carefully choose how to use allowed time to maximize help.

3. The most precious resource that the teacher has to facilitate self-teaching is the human nature of their students. A most correct description of that nature is written in Matthew 25:24: *"Then he which had received the one talent came and said, Lord, I knew thee that thou art an hard man, reaping where thou hast not sown, and gathering where thou hast not strawed"*. This means that every human being is endowed with an immense power and vocation for creativity and recursiveness that must be exercised in ordinary tasks that happen in any employment -if only courage is also present and abounds. Our preferred witness that this description of the

human nature is correct is that we have seen variously that students that get a nil or almost nil score in the first partial examination can get more than 4 in the second.

4. Given time constrains, the best possible use of the human nature as resource is to have students learn at home a clear material and solving proposed exercises while the class is directed to reinforce learned things, to create interrelations among concepts and to underline the whole structure of the scientific thought.

Strong warning: pedagogy is very hard and so no one can claim that he or she has the optimal solution for all problems. So, we celebrate the diversity of approaches and it is in this vein that we express our own experience: to enrich available options.

Now, if students are autodidacts, which could be the role of the teacher, if any?

### 4.4.1 Grilling

Our experience shows that some students, specially of advanced semesters and that eventually work in complete isolation, can work out the material to get an almost perfect mark. Most probably, they can do this after many false starts and lost attempts. But at the same time a significant proportion of students can only follow the examples almost blindly and as a consequence learn just a bit. So, the proposed role of the teacher along our methodology is to work over those incipient traces of knowledge to get a person that can relate concepts both one with another and with personal life. This process is done through exhaustive verbal grilling.

The art of grilling in its maximum expression has been known since ancient times under the name of maieutics, whose official purpose was to help students with appropriate questions to discover the truth (Wikipedia [30], 2012). Thus, maieutics aligns itself along our self-teaching project. This art is very difficult. A typical failure is to formulate a question that nobody can answer and that one does not know how to reduce to more simpler questions.

Students assimilate the grilling methodology and after some time a place is found for really delicate questions, as the next one: prove and explain what it means that when the number of data increases, it is more plausible to reject the null hypothesis. This assimilation is a sign of great progress: even if statistics is completely forgotten, the capability of arguing using very fine and detail technical argumentation will enrich their lives for ever.

### 4.4.2 Working in groups

All examinations are presented individually. By contrast, grilling, homeworks and the project are presented in groups whose size and membership are left to changing self-organization. Size may vary from 1 to 20, but more usually in within 3 and 7.

At the beginning of the class students write problems on the blackboard. Next, a voicing for grilling is given. A group is chosen, it stands before the problem to be investigated. One person is selected and a question is given. If he

or she answers, all members of the group receive a good point. Next, another question is given to another person of the same group. If the person does not answer correctly, interrogation is redirected to another group. At the meantime, the former group is allowed to work together and once its members get ready, they reenter the queue for grilling.

We see that grouping serves various purposes:

1. Makes realizable the personal interaction among teacher and students.
2. Serve as teaching workbench for those students that know more than their companions. Let us keep in mind that the teacher learns twice.
3. Students that fall behind are instructed on a personalized basis.
4. Enables a reactor of ideas where the creative power of thinking in group is seen at once.

## 4.5 Management: enabling and selection

Management is the art of creating the future. A real person uses many guides to take decisions to achieve his or her goals and this may happen rather unconsciously. Nevertheless, let us make in hindsight an evolutionary reading of our experience with our course of statistics. We discover a very simple procedure that consists in two parts: enabling and selection. Enabling consists in creating an environment in which the future you want could be a real possibility although in incipient form. Selection consists in propitiating the appearing and/or nurturing of the targeted future that it could happen with high probability if not with certainty and in its full force.

It is interesting to compare our criteria with those given by Lao-tzu [22] (l.c., 2500BP). Using our terminology, his teaching reads: the best management is no management at all. He projects the impression that his words are backed by a large experience and in fact his dictum seems plainly correct. Firstly, management is very costly and summing up over the infinite of time, it amounts to a waste of infinite energy and of other resources. Secondly, if the extant social environment is left to spontaneous auto-regulation, it will fall into a socially accepted equilibrium. Hence, social auto-regulation is the cure of every illness. Our alternative is more from the side of engineering: create an environment in which the desired output happens spontaneously. Nevertheless, this may be very expensive. By contrast, it seems cheaper and realizable to create an environment in which the target my appear with an acceptable probability although in incipient form, as a result of a combination of multiple factors, and then to enhance its probability of occurrence and its strength of form by a mechanism that we call selection.

Let us see how we apply these concepts.

## 4.6 Enabling self-teaching

Some determinant factors to enable self-teaching follow.

### 4.6.1 Clear material

Self-learning functions when the student has access to a clear material. To produce a material with such a quality is a very difficult task because the theme is complex even when one tries to simplify it at maximum. But without a clear material, self-teaching is not imaginable. The problem is that it is easy to write a material that the author and other teachers can understand. But our experience shows that it is very difficult to write a material that newbies could understand and understand at the required crazy pace. Nevertheless, if one can battle along a terrible evolutionary process, our experience shows that success is achievable.

The material is designed basically to follow a 1-1-1 pattern: one concept, one example, one exercise. But it has been found that problem solving is very difficult for the generality of students and usually they fail to transform an idea into a way for problem solving. Nevertheless, if examples are algorithmic, that show a series of steps to solve a problem, then problem solving becomes realizable. Example: the variance of a quantitative set of data is the average quadratic deviation from the mean. It happens that no one can convert this definition into a procedure to calculate variances. That impossibility remains alive even if one translates this definition into the usual sum of quadratic expressions. But if an example is shown in which a variance is calculated by means of a table with two columns, one for raw data and the other in which the quadratic deviations of each datum with respect to the mean are both indicated and calculated, everyone can solve the corresponding exercise at once. Why? The solution becomes imitable because a table is for this case a very cozy form of expressing the corresponding algorithm.

In general, if solutions are given in terms of algorithms, all what students must do is to find the pattern that the problem fits and to follow the procedure to solve it. In a later stage such an aid is not necessary.

It seems that a very important skill in mathematics is to convert a task as an idea into an algorithmic program to be executed. Our observations in this regard can be summarized as follows:

1. Beginners cannot transform a task as an idea into a task as an algorithm or procedure.

2. By imitation, this skill can be acquainted with.

3. A long way must be walked from imitation to full management, in which a student can successfully deal with the algorithmic implementation of tasks as ideas.

4. Our methodology enables a soft beginning of that difficult enterprise but it is unknown how much is advanced apart from the specific needs of the course, which in that regard are not very demanding.

Recalling that the genome is software, the encoding in genetic language of the algorithm that encodes for the continuation of life, and that evolution is a software developer, we are discussing how evolutionary methodologies for problem solving can be consciously planted in the mind of students. This fact

alone clearly illustrates how evolution is found not only everywhere but also in the most important places.

Indeed, every person uses evolutionary strategies, though rudimentary, in his thinking machinery. Let us see it from the stand of hardware. The brain contains a giant neural network with very high parallel computing facilities which are exhibited, say, in the tremendous associative capabilities that we enjoy and that eventually could be efficiently used to solve problems by means of evolution. Let us consider now the stand of software: since with a bit of work one can see evolution everywhere, then it is always true that the brain uses evolutionary strategies to solve problems. In fact, we are usually pray of indecision, a situation in which we don't know what option to follow because all alternatives have points in favor. This very fact shows that the brain runs or simulates various computing threads which must compete for surviving and that can be consciously or unconsciously mutated and recombined. This is evolution.

Why is it important for us to find evolutionary algorithms in the mind of each person? Because it enables us to easily argue that teaching is an illusion or maybe a perversion and that self-teaching is all to healthy pedagogy. Our reasoning is as follows:

1. Evolution per se is highly inefficient but if one helps it with oracles that come from outside, it eventually may become a precious tool.

2. Student invent and use cues to solve tasks and these are diverse for even slightly complex problems. This cues are the aforementioned oracles.

3. The intertwining of evolution and oracles that are used to create more oracles is a highly divergent process. So, we are all different one from another and that is why it is delicious to speak with everybody.

4. The divergence in thinking processes is similar to genetic divergence among individuals. Thus, teaching is to pedagogy the same as the transplant of organs is to medicine. Let us notice now that transplants are not part of ordinary life but of extraordinary science and, to say the least, they are rejected without immunosuppressants. Self-teaching is, by contrast, similar to nurturing in physiology and preventive medicine. Nevertheless, it is difficult to imagine efficient self-teaching without teaching, a fact that is best appreciated if we turn to physiology: the organism receives complex substances, bread and milk, which are degraded along the digestive process and resultant elementary building blocks -amino acids, fatty acids and simple sugars- are used as raw material to construct the organism following the specific to it rules. By the same token, self-teaching is more efficient when teaching in the form of appropriate bread and milk have been prepared beforehand.

5. In conclusion, mature teaching jealously serves self-teaching and not the other way around.

6. Pedagogy is very difficult and everyone is invited to look for exceptions to our rules everywhere around. Say, we all like stars, personages, great authorities. Why? Because they are exponents of things that cannot be neither learned or taught.

7. The reader is invited to become a star. The receipt to achieve this is well known: to unfold inner law and to work and work very hard and very wisely.

As we see, evolutionary ideas enlighten our understanding of the human mind. So, many people used to immediately conclude that evolution was the agent that forged it. This simplistic way of being is giving its place to more rigorous and more interesting studies. Example: Why are mathematics important? How must be the structure of a brain that it could support mathematics? Answer: mathematics is the art of solving problems not one by one but by discovering and developing techniques of general use, i.e., by abstraction. Early proposals about the brain presented a version that cannot support mathematics: it was compared with a Swiss Army knife, with several instruments of specific use, one module for hearing and another for vision. In that vein, more modern insights offer the metaphor of a brain as a human hand, which is enabled by its fingers and neural connections into a multipurpose instrument of a very different nature than the aforementioned knife. Thus, we expect a high degree of integration from a brain developed enough to support mathematics (Heyes [23], 2012).

### 4.6.2 Intuitive material

Self-teaching is more efficient when the material to learn is intuitive. This means that our examples and problems are fictions that everyone can recognize in ordinary situations. Example: *two girls played with a coin to get the maximum number of heads in 20 trials. The first girl obtained 18. The turn was for the second girl who refused to play and instead broke in tears. Explain why.*

### 4.6.3 The axiomatic methodology revisited

According to the directives of the Faculty to which students belong, every university student must know some mathematics. This must include to become acquainted with the axiomatic methodology no matter how difficult that could be. To implement this command, three fundamental constructive procedures have been included: the rejection of the null hypothesis for the probability of success of the binomial distribution, the construction of confidence intervals for the mean of a normal distribution as well as for the probability of success of a binomial distribution. We present two approaches for the confidence interval of the mean, one geometric, the other algebraic. Both methods are appreciated and both acquire fans.

### 4.6.4 Feedback at hand

Self-teaching means that the material is not explained by the teacher, instead it is intended to be read by the students at their homes, where they must solve the appointed exercises. Students can verify the answer with the solutions that come with the material. This represents the first way of feedback: students must make sure that they have correctly understood the material.

### 4.6.5 The problem of slower students

Nearly 40% of students go shoulder to shoulder with the schedule and participate in daily activities, but the rest seem to fall behind and to awake only when they listen the word "examen". To foretell this problem, the word examen is pronounced soon after the start of each period. That is why exercises are divided in two parts: the first comprises a minimum workshop that is developed to fill in the 1-1-1 pattern. The second part of exercises are encapsulated in the form of a pre-examination, with 3 to 6 different versions.

Since some people have phobias against examinations, pre-examinations could serve as a therapy. Moreover, people learn on direct experience that there is a strong difference between believing that one knows and to show under pressure that one is well prepared. Thus, students arrive on personal experience to the conclusion that they must study harder and to go on time with the schedule so that questions, doubts and intrigues could spring, be developed and solved...before the real examination.

To prevent an excessive delay in the preparation of students, once per week there is no grilling. Instead, the work appointed for that day must be presented in written form. This material is revised and scored by an assistant. Students are helped during the class time by the teacher in the execution of the task. But, if students prepared the task of the day in their home, they can prepare the next one in class and receive appropriate assistance. Nevertheless, many students like to hand over their work as soon as possible and to go away from the classroom. Other times they pressure the teacher for grilling to win extra points to improve their marks.

### 4.6.6 Born to work hard

The discipline needed to cope with the course is incredible. The best strategy to achieve this is to have students to be born to work hard. In consequence, students receive before the beginning of classes an e-mail with a welcoming message and with a task assigned for the first class. The task can be found in the attached pdf-book with all the material to be seen during the course. In response, some students ask by e-mail for specific help. Nearly 90% of students arrives to their first class with a done homework that is awarded with a good point for each solved problem.

But students do not arrive in the first class to show their work. Instead, they conform small groups preferentially of 3 members. In those small groups they compare solutions, mutually correct errors and when they have unified criteria, they go to the teacher to inform their success and to ask for the reward.

### 4.6.7 Work as a healing ointment

In spite of the clarity and intuitiveness of our material, the doses of work demanded from students by our autodidact methodology is very heavy. Nevertheless, we have discovered that students like to work, that work makes them happy if only it is appreciated and that work heals their fears that might be very strong. Example: a girl that feels a strong pressure to pass the course comes by the time of the third partial examination and confess for second time her distress because of the final examen. The teacher answers: to digest your

fear, work again over selected exercises to gain confidence and serenity. The girl accepted the advise, went on and never returned with the same or similar complaint. She made an acceptable examen and passed the course.

## 4.7 Enabling 5 in examinations

Our compromise with students is that it must be perfectly realizable to achieve perfect grades. But given that students must get well prepared, this is by no means easy. Various measures have been engineered in this regard.

### 4.7.1 The prompt of the University

Our university rounds notes to multiples of 0.5 units. The form as this is done is usually a matter of personal decision of the teacher but it is operationally cheap to approximate to the nearest neighbor. Thus, one may choose to approximate 4.75 to 5, although one may also approximate 4.6 to 5 if that is the maximal achieved mark.

This way of being reflects two facts. First: the high complexity of every course in the university and so absolute perfection is not realizable. Second, one can nevertheless be very proud of the effort made by many students to achieve excellence. In fact, we do know that our material is very complex because students that have not studied it at depth might receive 0 or 1 in their proofs even when they are allowed to look at the written material.

### 4.7.2 Complementary workshops

It is improbable to get various students with 5 in partial examinations. Nevertheless, experience shows that it is relatively frequent to find various notes of 4.8 or above. To enabling 5, we have devised 4 complementary workshops that can be solved to get additional 0.2 that must be added to 4.8 to get 5. If the student got a mark less than 4.8 and solved the additional workshop, he or she gains some additional good points for the score of daily work but not for the given examen.

### 4.7.3 Extra class

The Department of Mathematics orders to every teacher to help his or her students once per week during an extra class in special problems and questions. Assistance is not mandatory for students, but some like to use this opportunity to reinforce their knowledge but up to 10 persons may arrive, specially for the class before an examen. Additionally, an assistant also may offer an extra class and some students prefer the class with her or him than with the teacher. One apparent reason for this predilection is that assistants were former brilliant students that can show what to do very specifically without too much philosophy.

### 4.7.4 Delay of examinations

An usual request of students is to delay the date of examinations. A perfect agreement among them is required because examinations are scheduled since the beginning of the semester. But even so, students as a single man usually

demand to postpone examinations by one to six days, most usually one or two. The agreement is that the examination is delayed but not the appointed theme for each day. So, one continues the usual trend of work and for the next examination no delay is produced. But the teacher may feel that to overlap the work of two partial examinations is not a good idea. If that is the case, to do one or two quizzes could be more desirable. This produces a real delay in all the programming but this is not a big problem because in a sense examinations have been scheduled some 20 days before the corresponding dead line. This is a result of a measure specifically targeted to enable 5 in the final proof:

### 4.7.5 Space for a final review

There are four partial examinations and therefore, the semester is usually divided in four periods. Contrary to this, we divide the semester in five periods: four for preparing partial examinations and a last one for preparing the final proof. Daily work, tasks, quizzes and performance at the blackboard generate their own mark for each period worth 2% of the total score and adding up to 10% during the whole semester. If one is lagged off a whole week because of delays in partial examinations, we still have plenty of time for a good final review.

### 4.7.6 Final project

Students are committed to make an application of the course to their careers. This work amounts to 5% of the total score. Our directive is that this work must also serve as review of the overall material and an important mean to enable 5 in the final examination. So students are instructed to form groups of 4 and each students selects a partial examination and redacts and solves 6 problems related to it. This is done just after the fourth examination. There always have existed marvelous projects, full of creativity and almost perfect solving.

## 4.8 Selection in action

We have thus far discussed the problem of enabling of our target. Let us discuss now how selection has been implemented. The very first question in this regard refers to the exact definition of our target.

### 4.8.1 The one and only aim: students well prepared

Our purpose is to get students that in within the stipulated time can demonstrate with good marks that they are well prepared. Is this the most important objective or is it the unique one? We have chosen the second option. This means in practice that we subordinate all our activities to this great purpose. Example:

A person made in his written proof some arithmetic mistakes in intermediate steps but the final answer was correct. This is possible when errors balance one another. But the probability that two errors of different nature cancel each other is nearly nil, so it is a must for the teacher to formulate an explicit accusation of fraud. Experience shows that it is impossible to make a point of such an accusation unless the very same errors are committed by two neighboring students. Otherwise, one can try instead to use this occasion to help the student to improve understanding. Thus, one expresses the problem to the student and

submits him or her to verbal examination and, more to the point, with more time for extra preparation.

Students rapidly understand that the only purpose of the course is to get well prepared and so they dispense for other possible duties. The result is that the class is transformed into a market square: there are students that eat their lunch (the class is at noon) and even some attend grilling while consuming and sharing cookies or fruits, other speak by phone, a group of three male students looks at a football match using the wi-fi facility. A case was found in which a group of students played cards ... and argued that they were practicing with probabilities. One also finds other students that prepare their homework for another course.

### 4.8.2 Subgoals

Selection will show itself in its full force in the life after campus when students compete for works and performance. The tremendous responsibility of the university is to preview which characteristics and knowledge must a student have to guarantee good performance in the world where money is reign supreme.

In regard with performance, our model is simple indeed: a student will be good in life after campus when he or she can now learn and manage the appointed knowledge in the due time. If a student can achieve this, most possible he or she can manage a very hard project and to go beyond duty in his struggle for life. To gauge performance in our course, we have chosen the final examination because it is designed without the participation of the teacher.

Now, a terrible engineering problem arises: what shall be reinforced in within the semester to guarantee good performance in the final trial? Again, our answer is simple: divide the whole task in small portions, four in our case, and make for each portion a simulated final trial: these are the four partial examinations. And then we must ask ourselves: what must we reinforced in class to achieve good marks as in partial examinations as in the final one? Our choice is to preferentially reinforce work, understanding and interconnection of concepts.

Beware: the final examination does not fairly represents the whole content of the course. Instead, there are some themes that are worked out during the semester just for the pleasure of knowing where things come from but no one is interested in asking such things in the final examination. Nevertheless, the additional load is heavy.

### 4.8.3 Specific rewarding

The way as we implement selection is to reinforce with a good point those deeds and qualities that we consider important for achieving good grades in examinations. Good points add up together to conform the score of quizzes and blackboard, which counts 10% of the final grade. The following examples show how this is done:

1. Do you want students that work at home? Step one: enabling. Assign a feasible homework. Step two: apply evolution in the form of directed reinforcement. Say, each done problem is retributed with one point even if it is wrong.

2. Do you want to create students that love to pass to the blackboard? Declare an award for doing that. Passing to the blackboard to write a solution to a problem is worth one good point. Some people will express themselves saying that they hate the blackboard. Negotiate a big award if that fear is too deep.

3. What can we do to teach students to love to interrelate concepts? Enabling: subject students to grilling. Step two: pay one point for every good answer.

4. What to do when faithful students begin to collapse and have no time or force to make their homework? Indeed, adding the homeworks posited by all teachers, every student gets an amount of work that is overwhelming. And if it accumulates, disaster is expected. We can try to combat this trouble through enabling and reinforcement. Enabling is done if one assigns the amount of work in a righteous way. Next, reinforce the usage of getting with the schedule. Say, 3 points for the solution of a task with 3 problems and 2 more if it is presented on the appointed day. This additional reinforcement is done everyday pass the second partial examination.

5. Do you want good marks in the final examination, the one that is devised by the Department staff? The first step is to enable good scores. To that aim, assign some time to prepare it. Use the final examination as another opportunity to review the material, to relearn what once was learned and now is forgiven, to interrelate concepts. This takes time and so it is worth the fifth period of the semester and comprises some three weeks. The second step is to announce that good scores are important for you: promise special awards for those that get excellent scores. Say, you can add 0.5 to the score corresponding to daily work if the score in the final examination is greater than 4.4.

#### 4.8.4 The heavy load of life

We reward with one or various good points everything that looks to help getting well prepared. Students accept our politics and seem to enjoy it: one student said various times in reference to gaining a good point: *"it is addictive"*, and he voiced the very expression that one uses to prevent people about the great danger of psychoactive drugs. Additionally, students feel as an aggression if a good point is not payed when it is due and they fiercely battle until justice has been made.

In short, our selection mechanism is very strong, very powerful. Thus, one would expect a serious improvement of marks over the semester. But this does not happen. Instead, students seem to struggle for life and the load seems to be so heavy that to remain alive is enough to feel happy. Why? They are overcome by complexity and so they learn to live amidst rather humble results. This shows that wisdom is needed to correctly administrate pressure as follows:

#### 4.8.5 Mild selection

A wrong implementation of selection in management is to be too strict awarding only perfect products or behaviors with the hope that in this way high quality

will be faster produced. This is wrong because it is known that solutions to complex problems are usually the result of evolutionary threads that involve unfit individuals (Lenski at al [31], 2003). That is why we consider as a mandatory law to be tolerant. But, how much? We do not worry about that, instead we follow instinctive reactions at the moment in time.

In evolutionary terminology, we are not exercising perfect selection (only the best fitted is awarded) instead we use mild selection (a portion of unfitted individuals is also awarded).

#### 4.8.6 The value of the human side

No matter what one does, many students will perceive that they are battling with very complex themes. Where is the source of energy to overcome this barrier? The human nature can be used as a source of energy to overcome complexity. We already mentioned the potentiality for creativity, hard work and courage of the human being. These qualities enable self-teaching. Other qualities that are also in order follow:

1. Students like realizable challenges. When students pass a challenge, they are invaded by gladness. That is why many teachers consider that pedagogy shall not rest on external awarding but on inner joy. Nevertheless, our experience shows that students love being rewarded. Thus we have adopted it as permanent characteristic of our methodology. That is precisely why our project is naturally classified as evolutionary.

2. Students need to feel that they learn something important and that are well prepared. This aspect is very mysterious to us and our move has been to introduce the scientific method as something that everyone applies at every hour and that the purpose of the course of statistics is to update the natural, intuitive application of that method to fill in the standards of modernity. Actually, our material is very extended and one finds that students are prone to develop emotional ties for each theme, so they express their pleasure or distress caused by the local work. The feeling that we got is that the balance is in favor of general acceptance.

3. Students like to be appreciated, respected and eventually to be declared better than their companions and in any case no worse than close friends. This is precisely a powerful fuel to ignite an evolutionary environment in which the quest for perfection is driven by competence. This is seen every day in our class.

4. Students like to feel that they are trusted. We consider that this need is satisfied when a student fails to do the appointed homework. So, by default, it is assumed that he or she has a serious reason for that. So, he is not chastised but can present the work one, two, five, or fifteen days later, and receive the same award as if he presented the task on the appointed day. Nevertheless, for examinations we try to be more strict. If the need arises, we also reward going up to date with the schedule.

5. Students demand and like exceptional rules for exceptional deeds. Example: a student got 1 in his first partial examination. This was so disappointing for him that he broke in curses. He also tried to get from the

teacher special prerogatives such as the opportunity to repeat the examination. When he recognized that this was not possible, he made a serious decision to improve performance. He came to the teacher and asked for a form of bettering the so low mark he had. The teacher responded: "*you get a perfect mark or a nearly one in the exam to come and next we will see*". The marvelous thing is that he obtained 4.8 in the second partial examination, so he classified to make additional work to get 5 to the full. With it and instructed by the teacher, he stood before the whole class in plenum and said: "*the purpose of the university is not to kill the student but to teach, now I have proved that at last I have learned, so I demand that my extremely low score be remedied somehow in such a way that my permanence in the university is not threatened*". After a small negotiation in which various students participated, the teacher decided to change his 1 in the first examination by 2.5. Some time later a girl came alleging that she deserved a reward because she improved her score from 3.3 to 3.8. The demand was denied on the basis that no heroism is needed to do that.

6. Students can remake themselves. The Author has seen many diverse cases of students of both genres that have an extremely bad performance at the beginning but that then work very hard and achieve very good scores. There are other persons that have lost the course various times and that have many statistical data to firmly conclude that they are not born for mathematics. But something happens and they ruthlessly battle against themselves to achieve what is needed nor only for passing the course but also for attaining a high score.

These and other qualities of students as human beings are so precious in pedagogy that they never can be overestimated. The next subsection explains this from the stand of genetics, the science of heredity.

### 4.8.7 Phenotypes and genotypes

There is a distinction in genetics between phenotypes and genotypes:

- A phenotype is a characteristic that is directly exposed to the selection mechanism. In our system, a phenotype is anything that automatically gives rise to a score, say, a homework, an examination, a good answer in grilling.

- A genotype is the information that encodes for anything that causes or modulates phenotypes. The inner attitude towards mathematics, the willingness to work everyday, the joy of working in groups are examples of genotypes. The positive flavor of these qualities are inborn: we are programmed to feel joy when we understand, when we pass a challenge, when we can do something better than companions, when we succeed in explaining something.

- Genotypes in pedagogy seem to be directly tied with the intangibles of the human factor.

How important are genotypes? Genotypes in living beings are directly tied to chromosomes and DNA. If we delete the DNA-information from a human being, he or she still can live during, say, a month. But the quality of his or her life will rapidly decrease and death would be very soon preferable to such a poor life. The same happens in pedagogy: the human factor is a mine of infinite power to overcome complexity. We hope now that it would clear the statement contained in the next subsection.

### 4.8.8 The first duty of the teacher

Following our evolutionary insight, the teacher is the agent that executes selection: he or she declares what is good, bad or defective. This is done with words, gestures and scores. But this important aspect of the trade is not the most important.

From an evolutionary perspective, the first duty of the teacher is to enable the surviving of the teaching profession. This becomes possible if the teacher cannot be replaceable by an expert system, computer aids or similar facilities. Such a possibility is automatically enabled if the human quality of the student-teacher interaction is put in the first place. The rationale behind this is that human beings like to be human and deeply enjoy to be treated as persons. Under such a situation, students feel happy in class and as a consequence in a near future they will happily pay for their children to be treated as human beings. Correct management of the human factor will guarantee that future teachers will have an employment and that person to person interactions will be at the core of the teaching profession.

But concretely, what could be the pedagogic role a human student-teacher interaction? The only possible interesting role of a human teacher is to teach from first hand to be a human being. In this regard, we dare to say that a teacher that wants to promote humanness in his or her students moves from phenotypes to genotypes, from appearances to motives, from the face to the mind, from habits to the intention of the heart. In psychological terms, a human teacher that wants to promote humanness moves from operant conditioning (Maureen [32], 2001 ) to reeducation of motivation, to change of inner drives (Saitz [33], 2011).

On the other side, the possibility of education without teachers is real. In fact, computers have proven to be very useful teaching tools -just consider the tremendous success of Wikipedia. So, one could think that we must show that our methodology must outperform computer based education. Verily, that is not the case: we do know that pedagogy is very hard and so we celebrate the richness of approaches and their successes. We only highlight that person to person interactions can be posed as a constitutive ingredient of our activity and that this school in pedagogy will never pass away. Never.

*But a condition is needed: courage. Thus, the teacher is called to be a glorious king that inspires a wise and continued heroism at the same time that administrates justice and mercy, forgiveness and discipline.* Example:

Many students must overcome too many negative feelings at the beginning of the course. Students like to find that the teacher appreciates their effort and that this is specifically reflected in the scores. So, the teachers offered 5 good points to everyone that shows a battling spirit and that proves this by, say, getting up to date before the end of current week. When students learn that

a battling spirit is valued, they might come later with more related claims and demand a good point. The teachers satisfies the demand but -to propitiate a race for heroism - only if this is done publicly in front of whatever person could be by. In general, a politics of full openness and transparency allows the teacher to reinforce on the fly a good behavior, one that eventually could change the habits of study and the level and quality of feelings towards mathematics. Let us notice that we are dealing with remodeling of genotypes. This is another characteristic in favor of Lamarkism.

# 5 Results

There are various positive results of our project.

## 5.1 An encounter with the astonishing human nature

The Author remembers that time when he was pray of the axiomatic methodology and he saw with pity at his students because their lack of intelligence and motivation. Because of pity, he was unable to charge the students with hard work and as a consequence they learned not too much and the net result was that the final examination turned into a nemesis.

That time is gone and is gone forever.

In fact, the Author has too many witnesses from his students showing that every person is incredibly smart and that his or her heart is filled in great vocation for motivation and heroism. But it is needed an appropriate environment that these qualities could be challenged, developed and nourished.

## 5.2 Satisfaction in daily work

The direct result of this project is that this course is anymore felt by the teacher as a karma but as a source of happiness and realization. Actually, the teacher experiences the possibility to be satisfied every day, every class, during every consult. This feeling is backed by the intense and continuous work of the students, among which there are many that also seem to enjoy daily activities.

## 5.3 Discipline

A substantial proportion of students (40 to 50%) works everyday. The tempo is fast enough to allow for the accommodation at the end of the semester of a good review for the final examination. This also allows to accommodate a third partial examination instead of the usual two before the dead line for retirement of the course (this can be done to avoid losing the course with the ensuing consequences for surviving at the university).

## 5.4 Excellence is possible

We are proud of every student that get 4 or more in the final examination. It is impossible to get so high a score without a very good understanding and automation of the most important thematics of the course. The proportion of

students that achieve 4 or more in the final examination is high as compared with other courses of mathematics for engineers dictated by the Author in former years: the tradition of getting at least 10% can be said that is well established.

## 5.5 Repeatability

According to the scientific method, a claim is interesting in the measure that other people could repeat the methodology and achieve the same or better results. Can we expect that from our results?

There are various factors needed to think of repeatability. For instance, accounted experience was lived in an environment in which very hard work is a firm and well established tradition. Additionally, the Author has a long experience with self-teaching. Actually, he learned of it when he was a student and moreover he employed the methodology with engineers during many years.

Nevertheless, the question on repeatability would be considered by many teachers as another sting of a naive scientific imperialism. The reason is that all teachers know that teaching is built around teachers and not around methods. In operational terms, this means that the personality of each teacher dominates the role of any method and so the most we can aspire to is to think of a method that is implemented by a teacher following his own personality. In this respect, we have some general infallible predictions:

1. In any milieu and under any circumstances evolution is a tool that helps. In this regard, evolution means to recurrently make changes, adjustments, to try this and that to see what functions better and what must be left to oblivion.

2. Very complex problems cannot be solved exactly but only approximately and this can be done in many diverse forms. So, every teacher that reads our material rapidly will imagine changes to make it more suitable to his or her personality, understanding and vision.

3. We predict that our material is a good starting point for the evolutionary process that every teacher must run to devise a good for him or her textbook. In consequence, the latex source has been declared public domain and a license to modify it at will is furnished for free. We consider that this is the right editorial doctrine for the future.

4. We predict that, apart from some tiny modifications, any further evolutionary experiment will be very expensive even if our material is used with proficiency: changes yet small can eventually trigger a shower of compatibility errors, whose correction generates more errors. As a reference in regard with the the Author, he revised and corrected the material everyday to remedy the troubles found in class. During some five semesters, the time employed to execute corrections was measured in hours per day, 1 or 2 and sometimes 3 or 4. Next, the appropriate scale of time passed to be a half hour and now it is in the order of ten minutes.

5. In any case, our material, such as it is, is intended to compete with the best in the trade.

# 6 Evolution as a reality

We have proved that pedagogy is very harsh (Rodríguez, [34], 2003). And now we claim that we have succeeded in an evolutionary experiment that deals with a very complex problem of teaching mathematics to lay people. It is important to realize now that these two statements contradict one another if they are taken in isolation. Why?

Evolution is an approach to problem solving. Evolution works. Everyday at every instant many people are verifying this. But evolution works because it is real and not a fairy tale. By this we mean that evolution must fiercely battle against complexity and if success is achieved, then one must find in the history record many instances of troubles, failures and long periods of no progress in spite of all efforts. Stagnation happens when one gets trapped at a local optimum. Stagnation is the more severe the more complex is the problem to solve and the more advanced is the evolutionary process. This is the signature of evolution.

So, where is the account of our step-by-step victory over great troubles? Where is a reference to utter and persistent failures that have accompanied us all along our evolutionary process and that remain with us today to stain our success?

Let us consider in first place the process along which our troubles with massive negative manifestations were defeated.

## 6.1 Troubles that have been defeated away

We know that the perfection of our material has been increasing because the number and magnitude of massive problems diminished from semester to semester:

There was a rebellion at an early stage, some 8 semesters ago, because some given themes were considered exceedingly complex although they were detailed explained by the teacher. In subsequent semesters, with improved material and less demands on the axiomatic methodology, such rebellions disappeared in spite of the fact that students were autodidact. Nevertheless, strong requests were made by the students for review classes with detailed explanations made by the teacher. Next, these requests disappeared but students were unable to solve many assigned problems. Now, these impossibilities tend to vanish: every problem is always solved by at least one person. The next goal is to increase the proportion of students that can solve the great majority of problems. The process of correction has followed the expected pattern:

### 6.1.1 Chaotic evolution at the beginning

Our self-teaching project hangs on the clarity and intuitiveness of the written material. Our experience shows that these qualities can be handmade. Nevertheless, this is easy to say but quite problematic to live: we claim that the only available route to achieve clarity and intuitiveness is to go over a very long evolutionary process. The fitting of the material may be estimated by the number and force of complaints that arrive from students, colleges and the faculty staff.

Let us highlight that our evolutionary process associated with the improving of the material can be described as a recurrence of a subroutine composed of detection of errors and the ensuing correction that generates more errors to be corrected. This is very similar to what happens with software development. The reason of this coincidence is that a book is software for human beings. But if a correction seeds more errors, one wonders whether or not such a process converges somewhere.

Our strategy has been to force convergence by resorting to the use of direct negotiation of corrections with students that arrive with a complaint. Our experience shows that after some 8 editions of permanent corrections, clarity finds its way at last: the number and magnitude of errors tends to fade away, and the generality of students can solve proposed exercises (curiously enough, there had been found students that can solve most exercises even from early editions and in spite of low clarity, so the clarity we look for is clarity for most people). Because of all this, our evolutionary process cannot be classified as Darwinian but instead it fits the type of evolution envisaged by Lamarck.

The magnitude and number of corrections of the written material seem to fit the tempo of ordinary evolutionary processes: chaotic evolution was observed at the beginning and during some five semesters with a high frequency of every sort of insertions, deletions, transpositions, recombinations. During this time, the number of pages of the pdf increased from 5 to 200. This chaotic process was ensued by a settlement in which evolution was dominated by small change that caused the inclusion of other 100 pages directed to refine concepts and reinforce procedures. Anyway, evolution is a never ending story because one always finds an opportunity to make an addendum:

### 6.1.2 Evolution is opportunistic

A student of eight semester of History said by the third partial examination that in his whole career he never had needed statistics and that therefore, the course was not that important and hence requirements could be relaxed. Nevertheless, when he encountered contingency tables, he said: *"statistics is very useful. I am going to rule my life by numbers"*. This comment impacted the Author so much that he decided to incorporate a contingency table with a qualitative analysis at the very beginning of the course.

We have illustrated how perfection have increased with time in our evolutionary process. But, where are the scars that the battle against complexity has left in our lives? Where is the track of imperfections that are ensued by more imperfections?

## 6.2 Utter and persistent failures

It is time to confess that shoulder to shoulder with the marvelous solutions of the final examinations that are made by the best students, we find today and always have found in the general population of students a mix of granularity, oblivion and false concepts. More explicitly:

### 6.2.1 Granularity

If we ignore the axiomatic methodology pointing to the interrelation of all concepts, what product is expected? We expect disconnected knowledge. But how large could be that disconnection?

Our experience clearly shows that the disconnection can be extreme with the creation of the phenomenon of the granularity of knowledge. This means that concepts are not connected in the mind of the students, instead they appear in their minds as tiny grains of dry sand that get dispersed by every sweet wind. Recurrent example: some students are found that according to their final examinations seemingly do not know that the deviation is the square root of the variance.

To try to remedy this specific problem, revision exercises were strategically included, but nevertheless, the problem persists.

### 6.2.2 Instantaneous knowledge

Because we have too much material to include in a modern course of statistics, we divide it in chapters with the ensuing consequence that different examinations could very disconnected. If we keep in mind that marks in examinations decide the surviving of the student in the university, then one discovers the tremendous ability of students to learn what is needed to get a high mark in the present examination while everything else is instantaneously forgotten. This oblivion happens effortlessly just because the grains of knowledge has no affinity with something more heavy than the wind.

To try to remedy this problem, revision exercises were strategically included, but nevertheless, the problem persists.

### 6.2.3 Undue connections

Very few students get a low score because their lack of knowledge. Instead, bad scores are mainly and traditionally due to the fact that students mix real truths with imagined ones. Very common is to try to solve a problem about proportions with a blind use of the methodology that deals with means. The possible cause is that the course makes emphasis on the mean but some students imagine that the mean is everything to statistics.

On the other hand, our 1-1-1 methodology tries to profit on the immense power of the associative memory of human beings. But the richness of ordinary life demands from the student an analysis of every situation in order to decide the methodology to solve the problem. Nevertheless, some students fail to do that analysis an rely on unconscious associations. Of course, they fail.

### 6.2.4 Very bad scores in final examinations

Nearly 3 weeks are separated for the preparation of the final examination and so, good scores are expected. But apart from the top ten, results are disappointing. More exactly, results are traditionally disappointing: the global proportion of students that lose the final examination is above 50%.

### 6.2.5 Final examinations in blank

A terrible fact is that some persons present a final examination in blank or nearly so or maybe with some failing attempts to do something. Some of these persons may had have regular grades during the semester and possibly were distinguished by a relatively hard work. This utter recurrent failure is shaming for us that are very proud of our great doses of personal assistance.

### 6.2.6 The thesis of conspiracy

The fact that nearly 10% of students achieve excellence in the final examination has been instinctively taken by the Author as the signal that his methodology is very good. Nevertheless, the first table of the appendix shows that similar or better results have been achieved using other book and the traditional methodology, in which the teacher explains the material to be learn. That is why it is reasonable to say that the methodology is not the fundamental cause of success in the final examination but that the reason must be looked for at the very teacher. But, how? Which is the mechanism?

The direct explanation is as follows: since the teacher is subjected to evaluation on behalf of the students, he conspires to consciously achieve a good score and so he makes his best that students could got good or in any case not too bad grades. Given the long experience of the teacher, such a conspiracy has been more or less realizable. A side effect is that the temporal data describing the global performance of his classes can be simply summarized as a random perturbation of a constant value.

Evolutionary summary: students and teacher all alike are enslaved to the power of selection.

## 6.3 The future is pregnant with stagnation

One of our main results is that teaching is anymore a torture but that it seriously contributes to the happiness of the teacher. This is a very dangerous situation because, given the complexity of the enterprise, the teacher will tend to make a standard of achieved results. From an evolutionary perspective, we might say that **stagnation is in general the evolutionary reward for any success**. It is interesting to see how we actually live and have lived this load:

### 6.3.1 The inertia created by complexity

We have worked very hard to improve the quality of our material throughout a long evolutionary process. Given so hard work, one would expect that the proportion of excellence augments in time. But our data are not enough to support this at the 0.05 level of significance. So, a question immediately arises: where all that effort has gone? We see that our methodology, self-teaching + grilling, looks now acceptable but we must conclude that all our effort has been absorbed by the complexity associated with the setup of the methodology while the welfare of students is not improved. This fact with mixed results is at the same time intriguing and disappointing.

### 6.3.2 The two-edged sword

If excellence has not been improved by our methodology, then one would like to ask: have the students with difficulties been benefited somehow in an ascending manner? Indeed, it is not excluded a negative role of our methodology. Two possible mechanisms support this fear. First:

In the measure in which the material is refined, it is more plausible to get good scores in partial examinations in within the semester. This causes students to feel security before the final examination and so they cease to study by the end of the semester. Were this the correct explanation, it would be expected that the number of persons that fall below 4 in that final examen would correlate with the number of persons that have a grade above 3.5 before that examination. This prediction was not supported by data.

A second mechanism that possibly converts our methodology in a danger for lagged students is as follows: in the measure that our methodology gets sharper it is more demanding. Those people that lack compromise shall find this situation dangerous, intolerable and therefore they are expected to drawback and perish but those that are prepared to enjoy it would find it enticing and so they are expected to work harder. The prediction reads: excellence (the proportion of students with a grade in the final examination above 4) and failures (the proportion of students that fail, because of retirement or lost of the course) will both grow in time. This joined phenomenon is known as the Matthew effect: *"For unto every one that hath shall be given, and he shall have abundance: but from him that hath not shall be taken away even that which he hath."* A finding in pedagogy that fits this effect have been reported (Stanovich, [35]1986). Our data points to an incipient Matthew effect that lacks statistical significance.

## 6.4 Some concrete measures

The group of students of the top ten (among nearly 90 divided in two sections) always are people with a great courage and discipline. But this is not the general case. Precisely, our present situation is that we as yet have been unable to consistently pass from a class that battles for passing the course to a class that battles for excellence. We suspect that that paradisaic situation is possible because some rare times one sees stupendous but transient generalized performance.

What can we try out to walk towards perfection? Let us discuss some ideas.

### 6.4.1 More practice less philosophy

The course in its present form consecrates nearly half of the time to explain why science is a handmade craft. Important as this could be, it is needed only to the half to get a high score in the final examination. So, one may decide to delete the useless part and to concentrate efforts on those things that are of direct practical interest for the student, i.e. to the study of ordinary tests without delving too much in the know-why. The Author verified the fruit of this directive in a course of statistics that was offered for students of third semester of medicine and biological sciences: the grades above 4 in the final examination

were 24 among 37. Another verification was made for a course of statistics offered to freshmen of social sciences following another book whose content was explained by the teacher: the grades above 4 in the final examination were 11 among 26 (see the first row of the first table of the appendix). Nevertheless, this is not a rule: occasions have been in which this methodology produced no mark above 4 in the final examination.

To restrict the course to the learning of calculating procedures might be a duty if by whatever reason one lacks too much time. Nevertheless, it is recommended to keep in mind that a university is intended to deal as with procedures as with the philosophy behind them. Thus, we will keep philosophy in spite of all ensuing troubles.

### 6.4.2 An appropriately biased review

The final examination is not targeted to discover geniuses but just to test the correct knowledge and comprehension of some minimal material. It corresponds to some 50% of the overall material of our course. This opens the possibility to design a biased review to make sure that the most important material is well understood. For the semester to come, we will use the project to enable such a biased review: students must concentrate on the minimal central thematic to make their projects.

### 6.4.3 More quizzes

Grilling has been the strong part of our methodology. This is complemented with corrections of written material once per week. Because the corresponding homework is made in groups, some persons may figure as authors when in reality they have realized no work. A remedy is to make quizzes that must be solved individually.

### 6.4.4 Motivation for heroism

We have seen that our situation is more or less stable in the sense that changes have been neutral with respect to performance of the overall class. This is consistent with the belief that students in general tend to have as individuals a given performance level which is difficult to rise. Nevertheless, we have found students that challenge themselves to strongly improve grades and success have been achieved. The only explanation of these two facts is that the performance level springs from many diverse factors that produce a robust average and therefore, one must exercise an almost heroic effort to visibly improve own level. But more astonishing, this has happened variously.

It is recommended to notice that the vocation for heroism is universal because sometimes it comes precisely from a person that one does not expect. So, what will happen if we promote heroism and a longing for it? Because this is so important, let us propose a definition of heroism that could be appropriate for pedagogy: heroism is the will for change to the good even when that is costly and hard, so heroism surpasses ordinary negotiations for change (Cowgill [36], 2012).

### 6.4.5 Promoting the feeling of understanding

A very strange characteristic of students is that from time to time they exclaim with a visible joy: I understood! And the teacher also is invaded with gladness when he or she hears such a scream of victory. What would happen if one reinforces the quest for such an inner experience?

### 6.4.6 Positive coherent behavior

From time to time one finds a class that is perceived as very good else as very bad. This is possible if all students observe a coherent behavior, in which all of them study hard for every day or, maybe, leave the study for the night before examinations. The possibility of coherent behavior is made into a treasure if one knows how to drive the corresponding bifurcation towards massive excellence. An evolutionary proposal springs immediately: reward coherent positive behavior. If one does this at the level of class, nothing good is expected as a rule. But one can try this at the level of groups of study of 3 or 4 students: if every student of the group gets more than 4 in the partial examination, everyone is added 0.1.

# 7 Conclusion

Ordinary life is an extremely rich evolutionary lab. To illustrate this in a non trivial concrete case, a pedagogic experience with a course of statistics for social sciences has been reformulated in terms of evolution. This exercise has been shown to be fruitful in regard with simplicity, power and elegance. We also see that evolution is the best tool to explain what complexity is: complexity is the characteristic of all evolutionary processes, be they Darwinian or Lamarckian, that cannot connect mediocre solutions with current and possible insufficient perfection if not through many intermediate stages that cause long and exacerbating stagnation. Since high complexity is ordinary and ubiquitous, this amounts to a mandatory prediction that is fulfilled by every true evolutionary process. Contrary to this, it is systematically violated by the supposed evolutionary process that according to Darwinian and Lamarckian evolutionary theories gave rise to the origin of species. In fact, perfection is all one finds as in extant populations as in the fossil record. So, these theories and their variants are all obviously false. But courage is needed to accept this. And much more is needed to try to concoct proofs that could be acceptable for other people. But it is because of your courage or of its lack that the history of the universe will judge you. And nobody can scape from this.

# 8 Appendix: Data

| Statistics for Social Sciences: raw data | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Course | St | Ret | S3.5 | D4+ | Lst | FE | Fe4+ | Max | LstFE | Book | Method |
| 200620.1 | 37 | 11 | 13 | 11 | 4 | 26 | 11 | 4.8 | 6 | Ord | Exer |
| 200710.5 | 37 | 8 | 18 | 11 | 6 | 28 | 8 | 4.7 | 14 | Trans | Exer |
| 200810.3 | 38 | 4 | 19 | 11 | 6 | 34 | 4 | 4.8 | 25 | Trans | Exer |
| 200820.3 | 33 | 5 | 22 | 13 | 2 | 28 | 1 | 4 | 18 | Trans | Exer |
| 200820.5 | 37 | 5 | 22 | 13 | 2 | 33 | 6 | 5 | 19 | Trans | Exer |
| 201010.2 | 47 | 15 | 17 | 9 | 6 | 32 | 4 | 4.7 | 22 | New | Grill |
| 201020.2 | 45 | 7 | 23 | 22 | 3 | 32 | 2 | 4 | 15 | New | Grill |
| 201020.3 | 45 | 8 | 23 | 12 | 2 | 29 | 3 | 4.1 | 11 | New | Grill |
| 201110.2 | 44 | 2 | 21 | 11 | 8 | 43 | 5 | 5 | 32 | New | Grill |
| 201110.3 | 45 | 13 | 24 | 15 | 0 | 32 | 5 | 5 | 16 | New | Grill |
| 201120.2 | 44 | 7 | 17 | 20 | 1 | 37 | 9 | 5 | 6 | New | Grill |
| 201120.3 | 44 | 7 | 10 | 14 | 7 | 36 | 7 | 4.6 | 18 | New | Grill |
| 201210.2 | 47 | 9 | 26 | 12 | 3 | 38 | 8 | 4.5 | 26 | New | Grill |
| 201210.3 | 46 | 9 | 19 | 7 | 6 | 37 | 3 | 4.4 | 31 | New | Grill |
| Sums | 589 | 110 | 274 | 181 | 56 | 465 | 76 | | 259 | | |

Encoding:

Course= year (2006), first or second semester (10 or 20) and section(.1 through .6).

St: number of students that began the course.

Ret: number of students that retired.

S3.5: number of students that have scores above 3.5 just before the final examination.

D4+: number of students that in the final grade got a score of 4 or above.

Lst: number of students that lost the course with a score or 2.5 or below.

FE: number of students that presented the final examination.

FE4+: number of students that in the final examination got a score of 4 or above.

Max: maximal grade achieved in the final examination.

LstFE: number of students that lost the final examination with 2.9 or less.

Book: the first course was dictated with an *ord*inary book, then some material was given by the teacher during a *trans*itional period, next the material given by the teacher was developed enough to allow *grill*ing as the fundamental ingredient of the methodology.

Method: an *ord*inary book is not understandable for students, so the teacher must explain it. The class is generally directed to show the know-how over *ex*ercises. To enable the *grill*ing methodology, a very clear material with the know-why must be available.

The previous table allows to compute relative frequencies:

| Statistics for Social Sciences: relative frequencies | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Course | St | Ret | S3.5 | D4+ | Lst | FE | Fe4+ | Max | LstFE | Book | Method |
| 200620.1 | 37 | 0.30 | 0.50 | 0.30 | 0.11 | 26 | 0.42 | 4.8 | 0.23 | Ord | Ex |
| 200710.5 | 37 | 0.22 | 0.62 | 0.30 | 0.16 | 28 | 0.29 | 4.7 | 0.50 | Trans | Ex |
| 200810.3 | 38 | 0.11 | 0.56 | 0.29 | 0.16 | 34 | 0.12 | 4.8 | 0.74 | Trans | Ex |
| 200820.3 | 33 | 0.15 | 0.79 | 0.39 | 0.06 | 28 | 0.04 | 4 | 0.64 | Trans | Ex |
| 200820.5 | 37 | 0.14 | 0.69 | 0.35 | 0.05 | 33 | 0.18 | 5 | 0.58 | Trans | Ex |
| 201010.2 | 47 | 0.32 | 0.53 | 0.19 | 0.13 | 32 | 0.12 | 4.7 | 0.69 | New | Grill |
| 201020.2 | 45 | 0.16 | 0.61 | 0.49 | 0.07 | 32 | 0.06 | 4 | 0.47 | New | Grill |
| 201020.3 | 45 | 0.18 | 0.62 | 0.27 | 0.04 | 29 | 0.10 | 4.1 | 0.38 | New | Grill |
| 201110.2 | 44 | 0.05 | 0.50 | 0.25 | 0.18 | 43 | 0.12 | 5 | 0.74 | New | Grill |
| 201110.3 | 45 | 0.29 | 0.75 | 0.33 | 0.00 | 32 | 0.16 | 5 | 0.50 | New | Grill |
| 201120.2 | 44 | 0.16 | 0.46 | 0.45 | 0.02 | 37 | 0.24 | 5 | 0.16 | New | Grill |
| 201120.3 | 44 | 0.16 | 0.27 | 0.32 | 0.16 | 36 | 0.19 | 4.6 | 0.50 | New | Grill |
| 201210.2 | 47 | 0.19 | 0.68 | 0.26 | 0.06 | 38 | 0.21 | 4.5 | 0.68 | New | Grill |
| 201210.3 | 46 | 0.20 | 0.51 | 0.15 | 0.13 | 37 | 0.08 | 4.4 | 0.84 | New | Grill |
| Global | 589 | 0.19 | 0.57 | 0.31 | 0.10 | 465 | 0.16 | | 0.56 | | |

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