

THE MEANING OF EDUCATION

A lifetime of Summer Schools

By

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Prologue

This is not only a book about my life. It is also the story of many others, colleagues, friends and students, who affected me deeply and who, I would like to believe, were also affected by me. Not only as a teacher and educator, but also as a co-traveler on a wonderful Odyssey, filled with unexpected, scary but also wonderful adventures, on the road to discover the meaning of education. Like Odysseus and his crew, we don't know if we have already arrived there unknowingly, or if we will ever arrive at Ithaca. Perhaps, we have now reached the island of Phaeacians, invited by Nausika, to tell our story at the palace of Alkinoos.

It has been so far a rather long and exciting tale of many stops at different Greek cities, where a great number of scientific discoveries of the past one hundred years were presented to Greek students, concerning the developments of a new discipline called *Complexity*, or *Complex Systems Science*. At the beginning of our journey in the 1980's, it was all about *Chaos*, *Fractals* and more broadly *Nonlinear Dynamics*, whose influence in all scientific fields was expanding at an impressive rate. It was clearly a revolution, because it had already started in the 1960's and 1970's to change the way we thought about astronomy, classical mechanics, statistical physics, chemistry, biology, economics and engineering science.

In the 1980's, Chaos and Fractals were already shining beacons standing on a firm mathematical foundation rooted in a deep understanding of *nonlinearity*, dynamically as well as geometrically. It had become clear that linearity was simply an approximation, whose set of tools would always accompany our endeavors, but could tell us nothing about the incredibly fascinating phenomena that lay beyond its reach. This is where our journey began, as an aftermath of an international conference on "Nonlinear Dynamics and Chaos in Classical and Quantum Systems", in August 1986, at Thessaloniki, the first of its kind in Greece.

It was at this meeting that some of us decided to build a "platform" that could travel in Greece from city to city to organize annually 2 – week Summer Schools, in which Greek university students would be exposed to the theory and applications of the new science of Nonlinear Dynamics and Chaos. We did not know at which shores this journey would lead us, how difficult it would be or how long it would last. All we knew was that there was an urgent necessity to sail forward, if we wished to participate as Greek scientists, teachers, researchers and students in the global revolution called Nonlinear Science.

This is the story of a journey that continues to this day. Its longevity is of course a proof of its significance, but the roots of its success are multifold: First, it was the great desire of most participating professors and researchers to meet and exchange ideas and experiences in a spirit of healthy competition and collaboration, inspired by the advances of Nonlinear Science around the world. Second, and most important, was the realization that if what we knew and were already practicing was not passed on to coming generations, Greece would not be able to follow and perhaps one day lead in the discoveries of the new science.

And so, our journey began with the 1st Summer School on "Nonlinear Dynamics and Chaos" at the seaside city of Patras in the summer of 1987. We then moved on to the island of Samos, which proved hospitable enough to keep us at its shores for the organization of the next 3 Summer Schools in 1988, 1989 and 1990. Next, we moved to the seaside city of Heraklion at the island of

Crete; then back to Patras, then to Xanthi..., but I am running ahead of myself. After all, you will have a chance to read about these adventures in the pages of this book. Let us return for a moment to some of the more scientific aspects of our escapades.

As new and far reaching discoveries emerged in the 1990's, the fields of Nonlinear Dynamics and Chaos expanded in diverse and more exciting directions. Our understanding of *low-dimensional* phenomena involving a small number of interacting variables became more consistent and complete, ushering a new era, where the study of large multi-dimensional systems became possible. These systems were named *complex*, mainly because it was the *multitude* of their (possibly infinite) variables that appeared to shape their behavior and not the detailed dynamics of individual components. To understand their *global* properties, new tools had to be invented, both conceptual and computational, modeling became of crucial importance, and the science of *Complexity* emerged aiming to understand and perhaps one day predict and control these fascinating phenomena.

It is indeed hard to overemphasize the importance of these developments. The formation of weather patterns, the occurrence of seismic events, the spread of epidemics, the evolution of interacting populations, the fluctuations of economic indices, the interpretation of our genome, the detailed function of our brain and even variations in social behavior began to be better understood. The science of Complexity appeared on stage claiming to provide a common framework and a unifying methodology, through which all these highly complicated phenomena could be better analyzed.

Thus, starting with the 9th Summer School at Patras in 1995, the word Complexity became part of the title of our Schools and has since served as the focus of many of the lectures and presentations. Still, even though it plays to this day an increasingly important role in many sessions, we have always strived to enrich our Schools with extensive references to the fundamental mathematical principles of nonlinear dynamical systems. As a result, based on strong theoretical knowledge, and equipped with an arsenal of powerful methods and techniques, we dared to venture into unknown territories, seeking to explore new lands and conquer heights previously thought unreachable.

Surprisingly, however, science has *not* been our primary concern on this journey. From the very first shores and islands we visited, we were all overtaken by the realization that the Ithaca we sought was not only scientific excellence, but also the true meaning of *Education*. As we grew and matured from year to year, we began to sense that all our efforts would prove futile and all our endeavors rendered meaningless, if we were not able to master how to communicate with each other. If we were to stay the course, there had to be an agreement on how the elders would teach and the youths would learn. The success of our trip rested vitally on what the experienced mariners could deliver and how the young sailors would respond.

Starting from the older folk on the boat, I cannot say we came prepared for the voyage ahead. We were, of course, professors and researchers of all types, and had already accumulated a certain amount of teaching experience, but it soon became clear that it was not good enough to handle a group of willing but restless youngsters. The students had not come to our Schools to work, think hard and forge ambitious and far – reaching plans for their future. They were there for the adventure, to enjoy some free days away from home and meet new friends. On the side, they would hear some new things about Nonlinear Dynamics, Chaos and Fractals that might prove useful to get better grades in their university courses.

From the day we set sail, we decided not to use any screening. All those who applied were accepted, there were no registration fees and free housing had to be secured in nearby university student dorms and adjacent camping grounds. The little funding we could scrape from our institutions and benevolent public or private organizations was used to cover the living expenses of the teachers. And the adventure began, with a lot of enthusiasm and excitement.

From the start of the 1st Summer School, it became clear that the stars of the show had come from abroad! They were the graduate students who had already traveled to faraway lands to do something called *research*, and had already obtained what was described as *results*, that could be used to get a master's degree in preparation for the pinnacle of achievements: A Degree of Philosophy that would give them the rite of passage to the world of real science. They had prepared their own *transparencies* and were now proudly showing them at the poorly lit large room of a seaside hotel in a series of pages filled with strange looking formulas and graphs.

There was no reaction. No questions were asked by the young sailors. What were they thinking? Perhaps "What is the meaning of all this?", "Why am I here?", or "Will I ever be able to do that?" were some of the unspoken questions that must have crossed their minds. In any case, they said nothing. The silence was broken by some of the older sailors, who asked questions and made remarks that must have sounded to the youths equally incomprehensible as the talks.

The elders began with a wonderful series of morning, early afternoon and late evening lectures, separated every hour by 5 – minute intervals, a 2 – 6 p.m. intermission for swimming and lunch and two 30 - minute coffee breaks. They did their best to introduce the basic mathematical and physical concepts of nonlinearity interspersed with simple examples and colorful pictures, explaining every detail with all the teaching and research experience they could muster. Again, there was no response by the youths. What was worse, was that the size of the audience began to dwindle. Evidently, we were sailing in the wrong direction.

A few days after the start of the School, I called a meeting of the elders at 10 p.m. around a long table in the garden of the hotel. "Dear colleagues", I started the discussion, "how do you think we are doing? Any conclusions so far?" Nobody spoke. We all felt there was something missing from the adventure we had just begun. Could it be perhaps a lack of *communication* with the youths? Or was it that we had not understood the *meaning* of education?

But, again, I fear I am running ahead of myself. The reader will have the chance to find answers to these questions in the pages that follow. Clearly, since we are now at the 32nd stop of this voyage, we must have done something right. Needless to say, of course, that we still do not know all the answers. But at every shore and island we stopped, we gathered new treasures, and fought new monsters on our trip to Ithaca.

This is the story of our travels and adventures on the road to discover the science of Complexity. On the way, our journey has taught us as much about Complexity as it has revealed about ourselves, the essence of teaching, the importance of communication between generations and the essence of education. In accordance with the ending of Cavafy's famous poem, perhaps we have now begun to understand "what these Ithacas mean."

CHAPTER 1

THE MEANING OF EDUCATION

Before I embark on my account of the travels and experiences of our Summer Schools, let me begin at the end of the story, to recount one of the main conclusions, where this wonderful journey has led us. It concerns what all of us who practice the labor of teaching are familiar with: the training of young minds to *learn* how to study, think, evaluate and employ the information acquired during a lesson. Let me start by saying that the mere act of lecturing on our part does not make us *teachers*, just like the mere listening by the young does not make them *learners*. I would like to reserve these terms for the occasion where they attain their true meaning, that is, when an act of *education* has been fulfilled.

Education is *not* the process of stacking information into the minds of the next generation, but *the art* of making these minds able to receive it. And they will do so only under two conditions: (a) if they respect the one who offers the information and (b) if they appreciate its importance. The first serves to prepare the ground, by making the mind ready to listen, and the second transforms information into *knowledge* that will be safeguarded for future use. If this transaction is successful, the information carrier is called a *teacher* and the young mind a *learner*. Otherwise, their communication is considered a failure.

These realizations appear so simple and self – evident that one might think they should be straightforward to implement. And yet, although they are much easier to apply on a one to one basis (think of a parent talking to a child), the art of elders educating youths is hard to institutionalize. As soon as one considers schools as institutions, where many lecturers attempt to communicate with a great variety of young minds, one readily understands how difficult it is to achieve between teacher and student *real* communication, capable of sowing the seed of knowledge.

Now add to these institutions, the requirement that they conform their teaching of every subject to a strict set of topics dictated by the Ministry of Education aiming to unify student knowledge on a national basis. In the case of Greece, this serves to give all high school graduates the chance to memorize the same information, which if properly regurgitated during an official examination, will enable them to enter an institution of higher education of their choice.

One might argue, of course, that such a process may be viewed as an “unavoidable”, “fair” and “objective” way to secure passage of the “worthy” from the stage of Middle to Higher Education. Now, imagine that a national education system, in its effort to find every year new exam questions, resorts to more advanced and conceptually intricate topics of Mathematics, Physics, Chemistry, Biology and other subjects. Naturally, all this specialized information cannot possibly fit in the *official* teaching program that the Ministry has imposed on Middle Education.

Thus, there emerged all over Greece a host of private “educational” institutes, whose mission was to help all youths aspiring to enter Greek institutions of Higher Education pass the Entrance Examinations. At a fair price, they would do so by training the students, through individual or group lessons, to solve the questions of the Exams by memorizing special “tricks” and “techniques”, as a supplement to what they were learning at High School.

And thus, all those who pass the Exams and enter the gates of Higher Education, mentally exhausted and happily relieved, quickly find out that *learning* is exactly *the opposite* from what they were told during their high school years. The shock is tremendous. First, they discover that all the intricate tricks and techniques they had to absorb to pass the Exams are now completely erased from memory. Second, and most important, they discover to their dismay that trying to apply the high school recipe of memorization fails miserably, as they are now required to think, evaluate, criticize and *understand*. How can they possibly break out of this stalemate?

Allow me, however, to set aside for the moment this highly complex problem of the “missing link” between Middle and Higher Education. After all, Greece is not the only country where such phenomena are observed. I intend to return to it at the end of the book, when the account of my travels will have hopefully brought me closer to the reader, so that we may together arrive at some conclusions and recommendations. Let me come to what we did in our series of Summer Schools, trying to bridge the less alarming gap between undergraduate and graduate studies in Nonlinear Dynamics and Complexity Science.

All of us who took part in these exciting travels, elders and youths alike, must at some point address some crucial questions: Why did we do it? What did we intend to do and what did we finally accomplish? What are the tangible results of our journey so far?

I hope, of course, that the reader will have the chance to find out in the chapters that follow. Still, I believe I owe you an answer in this chapter, where, after all, I am pondering the meaning of education. To be sure, our Summer Schools did not address directly the connections between Middle and Higher Education. Instead, we concerned ourselves with the transition from undergraduate to graduate education. We sought to find what the students knew and what they should learn more about the science of Nonlinear Dynamics and Complexity.

All along our sessions, however, it became evident that the courses the students had taken or were taking at their universities left much to be desired. Even though these students, by their mere presence at the Schools, showed interest in what we were presenting, it was clear from their reactions that what they heard from us differed significantly from what they had experienced in their university courses. The emphasis at our Schools was not on learning methods and techniques suitable for solving specific problems, but rather on understanding principles, concepts and ideas, whose value could be judged by their importance in current scientific papers, books and conference proceedings. The lectures delivered by the older teachers focused on introductory material that should constitute a foundation of basic knowledge, necessary to understand more advanced developments.

The younger researchers, on the other hand, working on their masters or Ph.D. thesis were more difficult to follow. To be sure, they gave the youths a feeling of what was currently being studied in these fields, in Greece and internationally. However, what was more important was that they all gathered together in the afternoons and evenings after each day’s sessions, in more casual settings, where the students could talk to the young researchers about their presentations and find out about their life and plans as graduate students.

We were never happy about the general structure of the Schools: Should the elders be more introductory in their presentations, were the different topics discussed in the optimal order, should we limit the breadth of issues addressed, must theory be described separately from all applications and experiments? We still don’t know.

What we do know is that we must have been doing something right. All sailors matured along the way. The teachers learned how to improve their lectures and the students discovered how to listen to them. Most of us had fun and great memories from every stop along the way. And may be, in hindsight, that was our secret: we found a way to combine fun with education and perhaps because of this, none of us will ever be the same again.

The main question is: What did we discover about the meaning of education? Can we formulate some conclusions in that direction? Before the reader goes on to find out in the coming chapters, let me attempt an answer at this point, recalling what I said at the beginning of this chapter. If we did fulfil some of the goals of our journey, it was because: (a) the speakers gained the respect of the listeners and (b) the importance of Nonlinear Science, and more specifically Complexity as a modern and important field of study, became abundantly clear, every stop along the way.

In brief, we succeeded to *communicate*, as a prerequisite of passing knowledge from one generation to the next and the epitome of what constitutes an *educational interaction*. Said differently, education requires an appropriate *social framework*, for the seeds to be properly sown and rich fruits to be ultimately reaped. To follow a certain scientific pathway, a student must first *look up* to those who followed it and be attracted by what they have achieved in their life. We, the elders, had to be role models, there was no way around it.

We were not all great scientists, outstanding achievers, or world experts in our fields. But we were friends. There was no antagonism, no spirit of competition, no hierarchy to recognize. There were exceptions, of course, but they were few and quickly set aside. The students followed our every move, evaluated us and judged us accordingly, every step of the way. There had to be *approval* on their part, otherwise the whole enterprise would collapse.

And one more thing: In all our escapades, science was *not* the only exclusive object of attention. Many other wonders of life were mentioned, discussed, argued and even practiced during free intervals and long after hour gatherings: History, politics, philosophy, athletics and, of course, the Arts, where several unexpected talents in guitar playing and singing often took the stage and were enthusiastically applauded!

We were, and still are enjoying this journey and its adventures. Out of the hundreds of youths that joined us at the first shores and islands as starry – eyed undergraduates, many came back to join us at later stops, as Ph.D. students, post docs, successful researchers and even faculty members, practicing Nonlinear Science and Complexity in many shapes and forms, in Greece and around the world.

Did we do everything right? Were we always successful in our endeavors? Of course not. But throughout this wonderful journey, with its Cyclops, Laestrygonians, Lotus Eaters, Sirens and Circe, I believe we began to discover and are still learning more about the true meaning of education.

And so, dear reader, comfortably reclining in your armchair, here is how it all happened...

CHAPTER 2

PATRAS AND SAMOS: THE FIRST STOPS OF OUR JOURNEY (1987 – 1990)

1. A Conference in Thessaloniki, August 1986

After a 10 – year career as a student and 5 years as assistant professor of Mathematics in the US, I returned to Greece in 1985, as an elected assistant professor of Physics at the University of Thessaloniki. I vividly remember a conversation I had on the plane with a fellow passenger in his sixties, chemistry professor at Thessaloniki, as we were getting ready to land: “So, you expect to make a difference as a new faculty member of our University? You honestly think you can improve higher education in Greece?” he asked with a sad smile.

“I sincerely hope so!” I readily replied. “Don’t put your hopes high young man,” the chemistry professor continued. “I had the same dreams when I first came back from the US and all I found was resistance, disappointment and failure”. I didn’t answer anything to the old professor. What could I say? I distinctly recall, however, a voice in my head saying, “Well, I definitely will try to realize my dreams, so that at least I don’t end up like you some day!”

My first academic year in Greece (1985 – 86) had barely started, when I learned about an associate professor’s position opening at the Mathematics Department of the University of Patras in the area of dynamical systems and differential equations, which is my specialty. I was told by colleagues in Patras that they viewed my candidacy very favorably and urged me to apply.

My first reaction was to go straight to the office of the Chairman of the Physics Department at Thessaloniki and lay out the situation to him. “Look,” I said, “I would like to stay here,” but will I be able to apply for an associate professor’s position any time soon?” He looked at me with a pessimistic expression and explained that no matter how much he would have wanted it, the Greek law did not permit such sudden transitions. I would have to wait for a “normal” period of 3 years before I could apply for promotion. There was no other way to proceed if I wanted to continue my career at the University of Thessaloniki.

Well, by the end of the year, I had been elected associate professor in Patras, but I didn’t want my stay at Thessaloniki to be unproductive in terms of my “dream” to contribute to higher education in Greece! So, I organized in the summer of 1986, at hotel “Philippion”, among the pine trees on a hill overlooking the city, the first international conference in Greece on “Nonlinear Dynamics and Chaos”, August 25 – 30. Somehow, my new colleagues helped me appeal to the proper university and government authorities and the finances were secured.

Many important scientists came to that Conference. I recall the names of famous US professors like Mitchell Feigenbaum, Martin Kruskal, Michael Lieberman, Alan Lichtenberg, Edward Ott and Celso Grebogi, as well as top Europeans like Giulio Casati, Carles Simo, Ian Percival and Otto Roessler. Many of them can be seen in the photograph in Figure 1 below: Doyne Farmer, of

Prediction Company and “Chaos Cabal” fame, is leftmost in the photo with a light brown shirt standing over a lady at the end of the front row who happens to be my mother! Four heads to the right of Doyne, on the top row is Robert MacKay, now Director of the Complexity Science Center at Warwick, while fourth and fifth from the left on the front row are Carles Simo, mathematician of the University of Barcelona and Edward Ott, physicist from University of Maryland.



Figure 1: Where it all started: International Conference on “Nonlinear Dynamics and Chaos in Classical and Quantum Systems”, Thessaloniki, Greece, August 25 – 30, 1986.

Eighth from the right is Alan Lichtenberg, University of Berkeley, fifth is Ko van der Weele, now Professor of Mathematics at the University of Patras, and just above him to the left is Marko Robnik, physicist of the University of Maribor, frequent speaker at many of our Conferences and Summer Schools and organizer of Nonlinear Dynamics and Chaos summer schools and conferences that continue to this day. Fourth from the right is Ian Percival, mathematician of Queen Mary College London, one of the main contributors to the theory of nonlinear conservative systems. At the center, on my left is Claude Baesens, University of Warwick Mathematics Institute, while on my right, with his feet in the water, is none other than the famous Princeton applied mathematician Martin Kruskal. And so many others....

There were several Greek professors at the Thessaloniki Conference who presented their work with enthusiasm and pride. Most important, however, was the attendance of many young Greek and foreign scientists, who came together to learn and discuss recent exciting advances in this new field in one of the first such conferences on an international level. The relations and planned collaborations that were forged that summer at Thessaloniki were frequently recalled by many of these young scientists in our later meetings.

Of course, I was not the only young Greek professor who had returned to Greece in the 1980’s. Many researchers in their thirties, were already there, mainly because of a new law, which had

created open positions at Greek universities and research institutions. Among them were the brothers Spyros and Stephanos Pnevmatikos, Kyriakos Hizanidis, Loukas Vlahos, George Tsironis, Astero Provata and many others. So, one afternoon, during that conference, we took a decision that was destined to bring an important change in the development of nonlinear dynamics, chaos and, more generally, *Nonlinear Science* in Greece.

We sat around a table and discussed the possibility of building a “boat” that would allow us to embark on a “voyage” of *Summer Schools* at different Greek cities, with the aim of explaining to young university students what this new field of Nonlinear Science was all about. It was perfectly clear in our minds that this was the only way of creating a generation of young scientists that would one day become outstanding researchers, capable of creating a tradition of Nonlinear Science in our country.

2. The 1st Summer School at Patras, August 1987

So, I promised everyone that upon arriving at Patras, I would start looking into ways to begin our adventure. Our “boat” had to sail from somewhere, and Patras seemed as good a port as any. First, I had to find the right location by the sea. I didn’t want to close us all in some big auditorium, where large classes were held. We did not have a Conference Center at that time. That came much later. Our voyage had to start at the shore, so I started looking for the right hotel.

There was, of course, the very attractive choice of hotels like “Porto Rio”, which remain to this date some of the most elegant but expensive locations for holding a meeting near the city Patras. However, if you are a starting professor, trying to organize a scientific event in the late eighties, such options were not optimal. So, after wandering around somewhat, I finally set my mind on a simple and modest hotel called “Rion Beach”, which I will refer to it for brevity as RB.

I am very grateful to the owners of the hotel, for helping us out on the start of our journey. In fact, we were to stop there again and take advantage of its facilities and picturesque surroundings in the years that followed. RB offered us a big room on the single floor above its restaurant, where there was a bar that we could use to serve coffee and refreshments during the breaks. There was no place to project the transparencies, so we had to borrow a roll – up screen from the university.

RB had a number of rooms, some of which could accommodate professors as singles, while younger participants could use the others as doubles to minimize cost. But they were not enough to satisfy our needs. We had to use some additional rooms at the student dormitories and find ways to transport those who stayed there to RB. There was little help from the university or government sources for supporting such endeavors, and it would all go towards covering the stay of the invited speakers. The rest of the participants had to pay everything by themselves.

There were about 90 participants, 70 of whom were students. Of course, there were no registration fees, since we didn’t want to risk losing the sailors before the journey started. So, I gathered all resources at my disposal, used my meager Department subsidy to buy notebooks, pens and bags, printed 100 copies of the lecture program at the university, loaded everything on my car and with the help of my students transported it all to RB. The first participants had already arrived and were sitting at the outdoors restaurant of the hotel getting to know each other over coffee. It was June 30, 1987, the sun was setting over the Patras bay and the “boat” was to sail 9:00 a.m. on the next day.

I recently asked one of my closest colleagues, Haris Skokos (now professor at the University of Cape Town!) who was at Patras in 1987 as a young undergraduate, what had impressed him most about the 1st Summer School. He thought for a moment, and then replied: “I had heard that you and some other professors were going to teach us about a new science. But when I saw you, I was shocked! I didn’t expect a professor could come to such a meeting wearing short pants!”

I never thought of it that way! It is true that most of the older professors I had invited came dressed in more conservative attire, but I and other colleagues of my age never thought this would make any difference. The important questions were: Would the projector light be strong enough so that everyone in the room could read the transparencies? Would the sailors stay awake after their lunch and afternoon break to understand any of the evening lectures? Alas, the answers were hardly ever affirmative.

To be sure, the evenings after 9:00 p.m. were extremely successful! Most of the older crew and, of course, the young sailors stayed at RB until midnight and had a wonderful low-cost dinner over Greek wine, discussing the amazing scientific wonders they had heard during that day. Naturally, the next day’s lectures always had to start a little later than planned. It was not exactly what the older folk had in mind, but one thing was certain: The “boat” had set sail and there was no telling what lay in store for us at future stops of our voyage!

By all accounts, the trip started on a good footing, steered by the School’s Organizing Committee that had been formed at last year’s conference in Thessaloniki. The morning lectures, delivered by highly esteemed professors like George Contopoulos from Athens, John Hadjidemetriou from Thessaloniki and John Nicolis from Patras were very successful. These “older” sailors made a conscious effort to explain the basic principles of conservative and dissipative dynamics in a simple and understandable way. We, the younger professors on the other hand, had come prepared for our talks not only with long sets of transparencies but also many pages of typed texts in many copies to be distributed to the audience. At around 2:00 p.m. we stopped for lunch and an afternoon swimming break.

Then, the evening talks began at about 6 p.m. Here, the organizing committee had asked Ph.D. students, completing their dissertation at some foreign or Greek university, to give short talks about their recent research on topics of nonlinear dynamics and chaos. The result was not what we had anticipated. First, there was complete silence during the first presentations, as the undergraduates in the audience looked at each other in desperation. Then we stopped for a coffee break at 7:30.

As the next speakers prepared their transparencies for the final session, most of the young sailors took their refreshments and descended to the restaurant on the lower deck. When the talks resumed at 8:00 p.m., the Ph.D. students realized that they were speaking to the members of the organizing committee and a lot of empty chairs. The older sailors did not dare to admit it, but there was a deep sense of disappointment. The voyage had started with the wrong wind blowing our sails.

We rushed to alter the course by changing the School program, so that some of the experienced lecturers spoke in the evening sessions. We also introduced “question and answer” periods between the talks. There was little improvement. As we were going to find out later at all stops of our journey, these Summer Schools were destined to meet the same difficulty and rise to the same challenge every time: How do you successfully sow new scientific concepts and results in young unprepared minds?

One remedy was immediately obvious but had not been scheduled in the School's program. It arose naturally in the form of late evening discussions during dinner time and beyond. Here the undergraduates realized that they could be themselves. They didn't have to pay attention to a lecturer, pretend they understood what was said and struggle to come up with a question. They could freely do what young people everywhere like to do: Get to know each other, find out what were each other's preferences, hobbies, likes and dislikes. Thank God there were no mobile telephones those days!

Thus, the undergraduates began to look forward each day to their evening get together. They could ask the doctoral students at which university they were studying, their professors about their topics of research, and how in God's name they could come up with results that the young sailors found totally incomprehensible. They shared some beer and wine and relaxed listening to the soft sound of the waves reaching the shore some 50 meters away. Then about two hours into the second or third evening session, one of the girls would turn to one of the boys and innocently ask with a voice that could be heard around the table: "Niko, did you remember to bring along your guitar?"

What were the professors doing there? Well, we were not all present. Some, a little older in age, would say "good night" at about 11 p.m. and retire to finish preparing their next day's lecture, or simply get some sleep. Some, a little younger, would stay and talk to the undergraduates. We enjoyed listening to their impressions and tried to answer some of their scientific questions. And, if Nikos had forgotten to bring his guitar, Simos Ichtiaroglou, then assistant professor at the University of Thessaloniki, would, after a little pressure, agree to produce his own. The Schools had started to produce their own culture, their own tradition that would accompany us for many years to come.

But, beyond these experiences, another very important tradition started at the 1st Summer School. We, the elder crew members, decided that all the effort we put in preparing our lectures and organizing the talks of the School should not be left scattered in the form of a few hundred typed pages of announcements, abstracts and copies of papers distributed to the participants. Even if the young sailors put this material in their bags, how useful would it be to them, until the next stop of the voyage?

We, therefore, made a promise to ourselves to publish this material in a book that would be distributed to all participants at minimum cost. And here it was where two of the most important co-organizers of the School, the brothers Spyros and Stephanos Pnevmatikos, a Mathematician and a Physicist respectively, offered their help in making this project a reality. They were not only two of the most prominent Greek researchers in Nonlinear Science. They also knew personally a publisher in Athens, called George Pnevmatikos (not a family relation) to help us realize this dream: Most lectures given at the 1st School would form the contents of the first volume of the series "Order and Chaos" (G. Pnevmatikos, Athens) that would be available by the time we reached the next shores of the journey.

And so, our trip began with favorable winds in our sails. We had overcome the first difficulties and made the first steps in realizing our goals. We the professors came to know each other better, understood the psychology of the young sailors and began to appreciate their abilities and limitations. But most of all, we realized that the success of this adventure required that we all treat each other as equal. There would have to be no rigid hierarchy, no single captain to give the orders and no officers to obey them according to rank. Our primary goal was a new science and how to

infuse a new generation with its beauty and achievements. We may not have suspected it then, but what we were really searching for was the true meaning of education.

3. The 2nd School at Samos and an International Conference August 18 – 26, 1988

The island of Samos, as everyone knows, is the birthplace of the great Greek Mathematician Pythagoras (570 – 495 B.C.). He lived at a time that Samos was ruled by the “tyrant” Polycrates, a powerful leader, who conquered with his army several of the nearby Ionian islands and ruled with an iron fist over their inhabitants. In fact, unhappy with Polycrates’ rule, Pythagoras left Samos around 530 B.C. and settled in Croton, southern Italy, where he founded a School, whose followers were sworn to secrecy and lived an ascetic life devoted to the study of Mathematics and its deep relations to the laws of nature. His teachings distinguished him for their emphasis on the natural numbers as a guide to the understanding of music as well as the motion of the planets.

Spyros and Stephanos Pnevmatikos are second and third from the left, on the second row from below in Figure 1. They were among the most vocal supporters of the idea of annual Summer Schools already from the start of the meeting of the Greek researchers at the Thessaloniki Conference of 1986. Spyros, born 1950, had studied Mathematics and Physics in France at the Université de Bourgogne in Dijon, France, and had obtained his doctorate on “Singularities in Symplectic Geometry” from the Free University of Amsterdam. His brother, Stephanos, seven years younger, had studied Physics at the University of Athens and had obtained his Ph.D from the University of Dijon in Solid State Physics in 1982.

All three of us were destined to be the main organizers of the first few of the Summer Schools and guided our vessel from Patras to the port of Samos from 1988 to 1990, when Stephanos met his tragic and untimely death on November 27, at the Research Center of Crete, while he was teaching numerical analysis to graduate students. On that fateful evening, together with Stephanos, another great, young and widely accomplished Greek scientist, Vassilis Xanthopoulos, was killed by the bullets of a demented youth, at an unparalleled event that shook the scientific community around the world.

Our voyage around the Greek islands was destined to have its victories and losses over the years, but back in 1988 we were only aware of the great opportunities that lay ahead. So, Stephanos, Spyros and I decided that it would be a great idea to combine the 2nd Summer School of 1988 with an international conference on “Singular Behavior and Nonlinear Dynamics”, at the Doryssa Bay hotel, near the village of Pythagoreion, not far from the capital of the island and close to the airport of Samos, so that our invited speakers from many countries around the world could arrive easily at the venue.

School attendance had not dropped: There were still 70 young sailors and 15 elders still on board. The students and many of the Conference’s younger participants could find cheap lodging at Pythagoreion, while the main speakers would reside at the hotel where the lectures would take place in a nice conference room. Spyros, Stephanos and I had invited many eminent scholars from European and American universities. Fortunately, we were able to get support from the newly founded University of the Aegean and thus could help with covering the living expenses of most of the foreign speakers.

There are wonderful memories from this Conference that involved many of the participants. I do not wish to dwell on the scientific aspects of the event. Many of the lectures were included as articles in two volumes of proceedings published in 1989 by World Scientific, under the title “Singular Behavior and Nonlinear Dynamics”. Rather, I wish to recall the music! First on the beaches, where Doyne Farmer, one of the world’s experts in predicting chaotic time series and Simos Ichtiaroglou joined forces to show how a harmonica can combine with a guitar to play Beatles’ songs, among many other internationally known tunes of the time (see Figure 2 below).



Figure 2. J. Doyne Farmer and Simos Ichtiaroglou playing Beatles songs for the benefit of students of the 2nd Summer School at Samos, August 1988.

However, the most successful musical event of the Conference and 2nd Summer School took place one evening at a small taverna located between Pythagoreion and Doryssa Bay hotel. It brought together a number of Greek and foreign musically talented scientists, who recorded the famous “Karlovasi Blues” inspired on the spot by the Mathematics lecturer of London’s Queen Mary College Franco Vivaldi at the harmonica and Simos Ichtiaroglou at the guitar. The improvised ballad was admirably sung at that incredible session by all participants, led by the tenor voice of David Campbell then Director of Nonlinear Studies at Los Alamos Laboratory (see Figure 3).

Various other cultural activities were also held during the Conference and 2nd Summer School at Samos. We visited the archaeological site of Heraion, a large sanctuary dedicated to the goddess Hera, built around the 8th century B.C. and located near Pythagoreion. We also paid a visit to the Museum of Samos at Vathi, which contained in its collection besides pottery, bronzes, and clay figurines, the colossal ionic statue of “kouros”, standing at a height of almost 5 meters. Finally, we took a tour of the famous 1036-meter-long Eupalinon Tunnel, near Pythagoreion, built by the great engineer Eupalinos in the 6th century BC to serve as an aqueduct for the city of Samos.

The question for the students, as well as all other participants of the Conference (not completely understood to this day) was how Eupalinos managed to drill the tunnel with two teams starting from opposite sides of the mountain and meeting at the middle with only 2 meters distance between

them! Another historical highlight was the famous “cup of Pythagoras” having a small hole at the bottom, from which all the wine drains suddenly once the contents have exceeded a designated level! This “bifurcation” phenomenon was immediately explained to the students by none other than the famous French mathematician Rene Thom, as an example of his “catastrophe theory” invented by him nearly 20 years earlier!

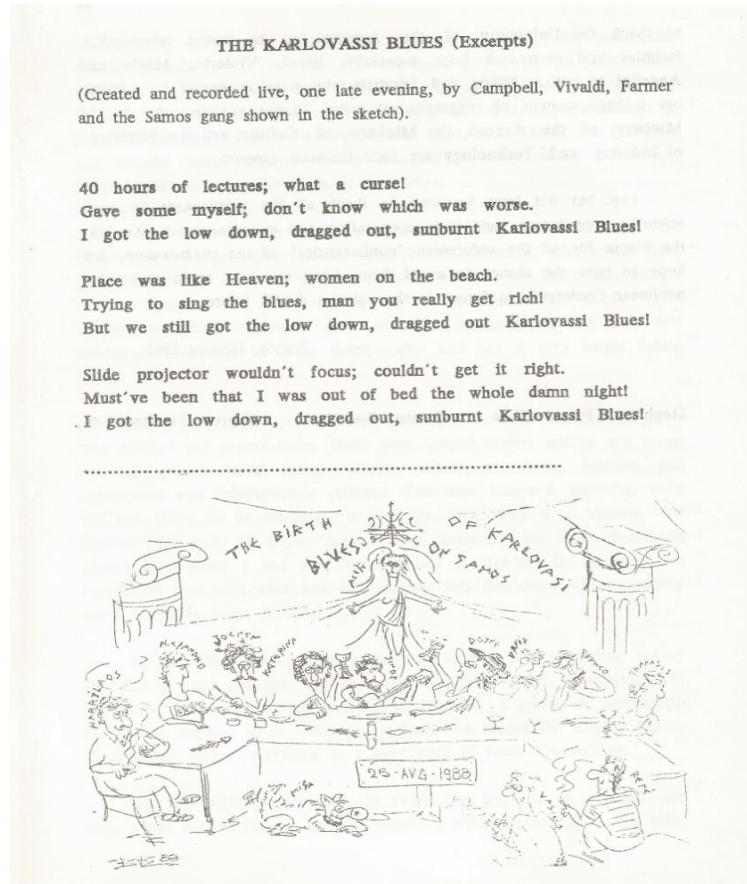


Figure 3. Above: The improvised famous “Karlovassi Blues” of the Samos 1988 Summer School – Conference. Below: Some of the song writers and singers caught in the act: Doyme Farmer on the left with the brown hat and Franco Vivaldi center with harmonicas, with David Campbell singing in between them and Simos Ichtiaroglou on the right with his guitar.

All these experiences were great for the elders but offered no consolation to the young sailors who understood very little of the scientific program of the Conference. To be sure, it was interesting to meet all these famous mathematicians and physicists and hear them talk about important ideas and recent trends in Nonlinear Dynamics. But that was not the point. They were not coming to Summer Schools to hear advanced lectures, visit archaeological sites, go swimming and attend musical events. As far as they were concerned, the voyage was straying dangerously away from its course towards the meaning of education.

They, therefore, had to be reassured that the following year's 3rd Summer School would be very different. We announced to them that it would also take place at Samos, but this time the organization would be primarily educational, focusing on the foundations of nonlinear dynamical systems and chaos. Moreover, beyond discrete dynamics, we would also introduce them to the fascinating subject of nonlinear waves in various physical media. And thus, we parted with a promise made, that had to be kept in the summers that followed, if we wished our journey to continue in the years ahead.

4. The 3rd and 4th School at Samos 1989 and 1990

Samos has a population of nearly 6000 inhabitants and two main cities: Vathi (the capital) and Karlovassi, which houses today the School of Natural Sciences of the University of the Aegean. We decided that it would be more convenient this time to organize the 3rd Summer School at the capital, whose location is more accessible (Karlovassi is at the other side of the island) and has more rooms for the lodging of students and teachers than Pythagoreion. Moreover, nearby beaches are also available for the afternoon breaks.

Stephanos, Spyros and I had invited to Samos in August 1989 a number of distinguished foreign scientists to take part. Some Greek professors and senior researchers had also come from abroad and there were about 30 students present at the shores of Samos eager to find out what the voyage would offer them this time. The "only" problem was: there was no lecture hall in sight!



Figure 4: Left: The capital of Samos (Vathi). Right: The Town Hall (Dimarheion)

"Not to worry", Spyros and Stephanos explained to me. "Since our mother comes from Samos, met our father here, and one of us (Spyros) was born on the island, there is one thing we should do: Go see the Mayor!"

And so, we went to meet the Mayor of the island, Petros Gryllos, who immediately welcomed us at the Dimarheion (Town Hall) shown in the photos of Figures 4 and 5. He generously offered a big room where the Town Hall meetings were held on the first floor. There were lots of nice (though a bit creaking) wooden seats, a big stage, and a high ceiling with open windows that brought in fresh and cool air, together with some birds that often wandered in to hear the evening lectures.



Figure 5: 2nd Summer School, Samos, July 1988, in front of Dimarheion (see Figure 4).

Front row from left: St. Pnevmatikos, G. Theodorou, Sp. Pnevmatikos, P. Gryllos (Mayor of Samos), T. Bountis, B. Grammaticos, J. Hijmans (University of Amsterdam). Behind us are some of the students several of whom are today accomplished scientists in Greece and abroad.

There remained, however, one major issue: We had no screen to show the transparencies! I looked at Stephanos and he looked at me. Something had to be urgently done. We jumped on the stage and found behind the curtains a large wooden framework and a pair of white sheets, that served as props for some of the Town Hall performances. Somehow, we stitched the sheets together, nailed them on the framework and raised the whole contraption in the vertical position supporting it upright with tables and boxes that we found backstage. The 3rd Summer School on Nonlinear Dynamics and Chaos was ready to begin!

Many of the lectures were in English, but some of the Russian speaking scientists were not so comfortable with that language. So, we had to rely on some of them who were English speaking to make the translation! I vividly remember the great Ukrainian physicist Alexander Davydov speaking to us about the Davydov solitons as nonlinear waves that were already becoming famous in the study of energy transport in Solid State Physics. He had come together with other Ukrainian physicists invited by Stephanos and supported by a common research grant between their universities in Ukraine and the Research Center of Crete.

The student sailors were absolutely thrilled with what was happening. This was nothing like last years' experience. This time they were going to learn about nonlinear dynamics and chaos. In the first few days they followed the lectures religiously. They came to the Town Hall at 9 o'clock

every morning and returned after the break at 6 o'clock every evening. They listened to the speakers attentively and even asked some questions. This, however, soon proved to be somewhat straining for their power of concentration. They began to feel a little tired of the lectures and started to look for some extracurricular activities.

Since they generally came from different universities, the young sailors decided to get to know each other by exercising the principle of self – organization: They formed groups and began to explore the city of Vathi and its surroundings. They discovered nearby beaches and high school playgrounds to exercise their expertise in basketball. Some even contacted the island's main radio station and arranged to give interviews on their trip and explain what brought them to the shores of Samos.

“So, what is a dynamical system?” asked an innocent radio interviewer the group of students visiting the station. There was a brief silence soon broken by one of the girl students, who ventured to answer: “Well, you take a function $f(x)$ and you apply it to some value of x to get a new value x' , then you apply it to x' to get a new x'' , and so on.” The interviewer didn't speak for a moment, then asked politely: “Well, what do you think of our island?”

I remember one hot afternoon, around 5 o'clock, walking down the hill with Stephanos from our hotel to the Town Hall, when I asked him somewhat worried: “How many students do you think will be present at the start of the evening session this time?”. He looked down at the beautiful port of Vathi and the inviting sea that surrounded it and replied: “Let's hope the speaker will be there...”

Still, the lectures were well attended by both students and teachers. After the end of the evening sessions, we often walked to a nearby restaurant and grouped around big tables to continue the discussions. We had several Greek speakers in our midst, who were eager to explain in more detail the concepts they had introduced in their lectures. Questions regarding nonlinear differential equations were raised and the possibility of their solvability was discussed. The elders tried to clarify that if these equations could be solved analytically, there would be no chaos and life would be clear sailing! On the other hand, if this were not the case, the equations could be solved numerically on the computer and then all the amazingly beautiful intricacies of chaos would be revealed!

It is not easy to combine vacation and learning. I recalled how Odysseus' comrades grasped every opportunity to enjoy life when they reached some inviting shore inhabited by lotus eaters or the sacred cows of Helios, unsuspecting about the danger of losing sight of their ultimate destination. Still, the 2nd School at Samos was a great success and remains vivid in the memory of many of us. One day, in between the morning and evening lectures, Stephanos and I hired two big boats, filled them with students and visited a faraway sandy beach that could only be reached from the sea.

After swimming aimlessly on their own for a while, the students found a ball and decided to play a kind of water polo. They formed two opposing teams and carried the ball in shallow water, trying to score a goal passing the ball over the head of the last player of each team, who had the role of a “goalkeeper”. Stephanos led one of the teams and I headed the other. There were supposed to be violent clashes, but we soon realized that when the ball was carried by Stephanos or me, the students, out of respect, stepped aside and allowed us to proceed without a struggle! Well, every plan has its drawbacks. Despite one's best intentions it is not always easy to mix generations!

In fact, the 3d School of 1989 was so successful that we decided to repeat the adventure the following year in a similar way. We were now older and wiser. Some of the sailors had begun doing graduate work with many of the elders and were making their first steps towards a Ph.D. thesis on nonlinear dynamics and chaos! Moreover, volumes 1 and 2 of the series “Τάξη και Χάος” (“Order and Chaos”) had just been printed by the publishing house of George Pnevmatikos in Athens. They were filled with introductory lectures written by the older sailors in Greek and were based on the talks that had been given at the first two stops of the journey.

These volumes continued to be published in the years that followed and served as scientific memoirs of our journey. They were offered to the students at low cost and are now in our libraries to remind us of the stops we made and the stories we recounted during our trip. But let’s return to our story.

The School of 1990 was very much like the ones of 1989 and 1988, except that the number of young sailors had dropped somewhat. Indeed, such fluctuations occurred naturally throughout the course of our journey. If I were to venture an estimate, I would say that the average attendance over the years was about 40 students and about 15 Greek lecturers at each School.

Back in 1990, however, a qualitative “phase transition” became evident to all of us. Some of the young sailors that were aboard since the beginning of the journey, were becoming a lot more knowledgeable and better equipped to give informative interviews at the local radio stations! Indeed, now that they were more experienced in listening to professors coming from far away universities, they began to discover that English is not such a hard language after all to read and understand. Some of them even tried to pose questions to the foreign lecturers.

The most favorite one of them was: “When can we say that a dynamical system exhibits chaos?” This was generally answered by what must have sounded to the students like a Pythian oracle: “Chaos often follows a transversal homoclinic bifurcation and requires the existence of a dense set of unstable periodic orbits”. The silence was broken by one more desperate attempt by one the young sailors: “And where can we say that chaos finds useful applications?”

“Oh, that’s easy,” replied the foreign professor: “in nonlinear lattices of solid state theory, for example, beyond the level of FPU recurrences, or in hydrodynamic turbulence, following the Ruelle – Takens scenario”. The embarrassing silence was broken only by the sound of birds flying through the high windows. Then came the professor’s ‘coup de grace’: “Even in quantum mechanics, whose equations are linear, chaos appears in the spacing distributions between energy levels!” At that point, the young sailors thanked the speaker and ran to the door. It was time for dinner.

Matters were more productive for us, the older Greek sailors. We had a golden opportunity to speak informally to our foreign colleagues about science and advance our own research, as we relaxed at the island’s comfortable surroundings. I vividly remember one such occasion, sitting by the sea with the famous professor of Queen Mary College London Ian Percival.

I was working at that time on the problem of singularities of dynamical systems in the complex domain and was stuck on a subtle question, which I posed to him one day at the beach. He gave me a brief answer, which I vaguely understood. When I thought about it again, however, one month later, I solved the problem, and wrote two papers with Ian Percival and my first Greek Ph.D. student, Lambros Drossos, who was then finishing his thesis under my supervision.

And so, Samos proved to be a very useful and enjoyable stop for all the elders and most of the young sailors on board. A new decade had started and the 3rd volume of “Τάξη και Χάος” was ready to be published. Our voyage had won many senior followers from faraway lands, who were beginning to understand that something important was happening in Greece on the topics of nonlinear dynamics and chaos. A successful International Conference had taken place that led to two volumes of proceedings, where Mathematics and Physics were magically combined to understand a wide variety of theoretical, numerical, and experimental nonlinear phenomena with a great number of intriguing applications.

Was it time to move to different shores? We did not know. But then, who could have predicted the events that followed? Surely, not even the best experts in chaos and nonlinear dynamics could have imagined what life had in store for the future of our Summer Schools.



Figure 6: Stephanos Pnevmatikos (1957 – 1990).

It happened in the evening of November 27, 1990, around 8 p.m., while Stephanos Pnevmatikos and Vassilis Xanthopoulos, two of the most accomplished young researchers and promising scientists of Greece, were explaining to graduate students at the Research Center of Crete the use of symbolic languages in performing difficult calculations on an electronic computer. A psychologically unstable youth entered the room holding a hunting rifle and began shooting. Several participants were injured as the youth emptied his rifle and then fled, running away to a mountain, where two months later he took his own life. Behind him, he left Stephanos and Vassilis in a critical condition from which they never recovered.

The shocking news traveled like lightning around the globe and shook the scientific world everywhere. For all of us, Greek colleagues and students of Stephanos and Vassilis, time came to a halt. We never expected that Cyclops could come to life and cruelly take away two of our most distinguished fellow scientists. But, at the end of that fateful year, we all made a solemn promise to ourselves: For the sake of Stephanos and Vassilis, for everything they stood for and taught us during their lives, we would never abandon the voyage. Now, more than ever, we felt we had a mission to fulfil: We would continue our travels to discover the meaning of education, more dedicated and determined than ever.

In 1991, the 3rd volume of “Τάξη και Χάος” went to print with a special dedication to Stephanos, a summary of his life and scientific contributions, a moving statement by his students, and a long paper he had just written for the book entitled “Sine Gordon Solitons and Long Superconducting Josephson Junctions”. At the beginning of the volume there was a copy of the announcement that had already been sent around the world: The University of Crete would give an annual award for outstanding teaching and research, one year in the name of Vassilis Xanthopoulos and one in the name of Stephanos Pnevmatikos, to selected scientists in their respective fields.

I was then called by Professor Eleftherios Economou, Director of the Research Center of Crete, to supervise the organization of a NATO Conference, already carefully planned and laid out by Stephanos to take place at Heraklion, May 21 – 25, 1991. It was entitled “Proton Transfer in Hydrogen – Bonded Systems”. I naturally accepted, even though I was also planning at that time a NATO Conference on “Chaotic Dynamics: Theory and Practice” to take place in Patras, July 11 – 20, 1991 (see next chapter).

I must confess that to this day, among other citations to my work, I still see my name cited in connection with the proceedings I edited for Stephanos’ 1991 conference on hydrogen bonded systems. In a way, I still feel his presence in my life and believe that had he been able to follow us from heaven above, he would be happy with the way our voyage progressed.

As the reader will find out, we were to lose several other elder scientists along our trip in the years that followed, albeit due to natural causes. They were all very important to us and their teachings will be forever etched in our memory. But Stephanos was different. He was our hero and we will always remember him at the helm, giving instructions and pointing the way. We, the elder scientists, still on board to this day, feel very proud that we have persevered and followed our mission towards the meaning of education, in a way that Stephanos would have approved.