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Communicating mathematics in Europe

Episode 5: Eduardo Sáenz de Cabezón in Pisa

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Abstract
This paper is the fifth in a series on the theme of the communication of mathematics in Europe. This episode is located is Pisa and features the monologist and mathematical populariser Eduardo Sáenz de Cabezón. The topics covered in the course of the interview include: how to narrate mathematics in a show; how to reconcile research, communication and teaching; the communication of mathematics in Spain; the importance of training to be effective communicators; the interdisciplinary approach to communication; and much more. Eduardo and his versatility allow us to savour the wonders of a world in which the contamination between different fields becomes a richness, and the beauty of mathematics and its message are exalted with wisdom and care by the artistic sensibility that guides his popularisation activities.

Keywords Mathematics communication · Eduardo Sáenz de Cabezón · Big Van Ciencia · FameLab · Popularisation of mathematics

As in a quantum leap, I find myself sitting in a small, half-hidden restaurant in the centre of Pisa, a few steps from Piazza San Paolo all'Orto. The atmosphere is pleasant and the pastel colours of the furniture blend with the spicy smells that come from the kitchen behind us. When my two lunch companions—Eduardo Sáenz de Cabezón and my colleague Silvia Benvenuti, a mathematician and a real Pisan—and I are seated, we are overwhelmed by the friendly welcome of the waitress. With her engaging theatricality and her hybrid language that mixes the Pisan dialect with English and a little Spanish, she describes the menu to Eduardo, takes our orders and leaves, wrapped in a smile. It has not been easy to organise this meeting. We've been chasing each other by email for over 4 months. We tried to set dates and places to meet, comparing our appointments, but without success. Then, when we were about to throw in the towel, Eduardo received an invitation from the "Accademia dei Georgofili" for two talks at the Department of Agricultural, Food and Agri-environmental Sciences of the University of Pisa. And here we are.

It is just past midday and the first of the two talks will start at 4:00. Taking into account the time needed to walk to the Aula Magna, we have a full couple of hours available to speak and get to know each other better over our lunch. Eduardo is currently one of the best-known figures in the Spanish mathematical community both for his advanced research in the field of computational algebra and for his intense activity as communicator and populariser of mathematics.

"Where did your journey with mathematics begin?", I ask him.

"I decided to study mathematics just after finishing high school, in the summer of 1991. By this I mean that I am not someone who has loved mathematics since I was a child. It was not at all like that. I liked mathematics, just as I liked other subjects, such as history, art, literature, but I dreamed of becoming a programmer. I loved computers and I loved programming games. It was the beginning of the personal computer era. I had a Sinclair ZX Spectrum at that time and I wrote small programs with my friends. There was not yet a degree programme in computer science in my university or in nearby universities, but there was a specialisation within the degree programme in mathematics. Plus, I had a high

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school teacher who was really passionate about mathematics and had a lot of fun doing it. I loved his way of explaining and playing with mathematics, I was fascinated by his relationship with the subject. So, I started university with the intention of becoming a programmer or something like that. Then, there was an algebra lesson in which our teacher, Pilar Bayer,[1] explained Noether's isomorphism theorem[2] and it was there that I realised that mathematics was a powerful thing. It was a crucial moment. I remember that in the days leading up to that Pilar had asked us to prove that some ring was a field or something like that. I knew the definitions and I struggled for days with the elements and the properties of the elements. I proved what she had asked and soon after that she explained Noether's isomorphism theorem, which automatically implied that that was a field, and I said to myself, 'Wow! If this is maths, this is what I want to do!'" It was a sort of illumination on the road to Damascus, a revelation that offered a young student who was still unaware of the depths of the mathematical world the opportunity to look at reality with different eyes.

We pause for the arrival of the appetisers. A writing behind Eduardo and Silvia, which I had not noticed when we entered, catches my attention. The etching, which overhangs the leather backrest of the bench that runs along the perimeter of the room where we are seated, reads as follows:

Il primo pretto, il secondo schietto, il terzo senz'acqua, il quarto non s'annacqua, il quinto tutto vino, il sesto come il primo.

(The first pure, the second one genuine, the third without water, the fourth not diluted, the fifth all wine, the sixth as the first).[3] I accept the invitation of this verse and pour to drink to Eduardo and Silvia to toast the occasion (Fig. 1).

Next I ask Eduardo, "How do you combine your research work with your commitments as a communicator?" "By going crazy, that's how I do it", he replies with a smile.

A sip of wine and he continues, "I have to be very careful about my timetable. I'm a mess when it comes to organising; you've suffered from this too. So, it's really hard to keep the

Fig. 1 The author (left) and Eduardo Cabezón

two things going at the same time, but normally it's like that. I have tried to organise my commitments so that, depending on the state of my research, I decide whether I can travel or not. For instance, in November I cancelled all travels since I needed the whole month to think about a problem. And for me 'to think' means—given how I'm used to do things—first sitting at my desk, writing, reflecting, and discussing that problem with my students; then running, walking or anything that helps me to clear my head; then coming back to the problem. This phase requires time and quiet. To do things well, I need quiet. Then, I can start travelling again and I take advantage of the trip to fix the proof or to verify the correctness of the proof that my students are carrying out, to write the paper and so on. I usually look for seminars or conferences, answering the calls so I can choose. It's a bit complicated at first, but it works. Also, I'm lucky because I have a large group of collaborators. We understand each other and know the best way to work profitably. As friends and also as researchers, we can perfectly understand the rhythms of each other and respect them".

If you add to these commitments that Eduardo also gives a course in Computer Languages and Systems at the University of La Rioja in Logroño, the situation becomes very complicated. Silvia, who like Eduardo is engaged on all three fronts, nods sadly, but adds: "Doing research, communication, and teaching at the same time is difficult, but it's worth it". It seems obvious, but each of these facets really helps and gives substance to the others. You improve your research by communicating, and you improve your way of communicating by doing research and teaching. Eduardo agrees. But there is a challenge at the source that must be overcome.

Society looks with suspicion at those who devote themselves to mathematics, fuelling the myth of the "mad genius", holder of the innate and mysterious gift of understanding numbers and formulas, without thinking that mathematical intelligence is a quality present in our mind

[1] She is currently Emeritus Professor of the Faculty of Mathematics and Computer Science at the University of Barcelona.

[2] In group theory there are three isomorphism theorems, which apply with suitable modifications also to rings and modules. The theorems were originally formulated by Richard Dedekind (1831–1916) and later made more general by Emmy Noether (1882–1935) in her article "Abstrakter Aufbau der Idealtheorie in algebraischen Zahl- und Funktionenkörpern" (1927) published in *Mathematische Annalen*. In 1930 they were completely systematised by Bartel Leendert van der Waerden (1903–1996) in his book *Modern Algebra*, considered as the beginning act of modern Algebra.

[3] Legend has it that this toast was made in Segalari, near Castagneto Carducci (in the province of Livorno), on 19 October 1885 and that the poet Giosue Carducci accompanied each of the six lines drinking a glass of wine.

regardless of the fact that we exercise it or not. There are many people who have a bad relationship with mathematics and end up living in a state of deep frustration, just as there are people who like mathematics but do not generally publicly declare it for fear of sounding presumptuous, almost as if one were more likeable by showing one's ignorance of this subject than a passion for it. This is not a problem limited to some particular country, but rather an issue that we could define as global.

"What is the public image of mathematics in Spain?", I ask with interest.

"It is getting better. For instance, mathematics is much more present in the media. The current employment situation is also excellent for graduates in mathematics: it is the degree with the lowest unemployment rate. It's been like this for 3 or 4 years. And, due to this, there is now a great demand for enrolment in the degree programmes in mathematics. In our university we have 25 places available for first-year students and only a few years ago we did not even have 25 students. This year we received over 80 applications for the same programme and we had to make a selection. And this is happening in many other universities in Spain." This is also confirmed by a late-June article in *El País* [1] by Ágata Tímon, the communication director of ICMAT (Instituto de Ciencias Matemáticas of Madrid), mathematics is currently very popular in Spain, mainly for three reasons: a greater presence in the media, the high employment rate of graduates in mathematics, and students who attend degree programmes in mathematics being better than in the past thanks to the selection process.

I ask Eduardo to clarify the first of the three reasons better.

"When I say media I mean all of them: television, radio and newspapers", he says. "For instance, I was invited to a top radio programme in Spain not just to talk about mathematics, but as a member of society at large. And I was invited as a mathematician. This means that they think mathematicians have something to say about what is happening in the world. Right now, I'm participating in the 'La Ventana' programme,[4] both to talk about mathematics and as a mathematician who has something to say about politics, economics and all other current topics (Fig. 2). And I think this is a great result on a social and communicative level."

That mathematics in Spain is experiencing a golden age can also be understood by entering any newsstand. It is striking to see how many books on mathematics are sold as supplements to newspapers. Silvia, who lives in Barcelona, confirms this.

Fig. 2 During the radio programme "La Ventana" on Cadena SER

"Was there a particular moment when Spain realised that mathematics was important, or some situation that led people to think that it was time to know something more about mathematics?", I ask curiously before diving into the delightful, steaming *maccheroncini* that have just been served.

A short culinary time out and Eduardo replies, "I think it was a gradual process. I am not very objective about this, since I belong to the community of mathematicians and I might see things in a slightly distorted way, but the year 2000 was the World Mathematical Year and the Spanish Mathematical Society made many efforts at outreach and organised many events, making mathematics much more present around the nation. For instance, they carried out a statistical survey of the jobs held by graduates in mathematics. Everyone thought that mathematicians were only teachers or researchers, but then it turned out that they were actually working in many different fields. Then, in 2006, the International Congress of Mathematicians was held in Madrid. That was another fundamental moment for the Spanish Mathematical Society because there was the fortunate circumstance of the proof of Poincaré conjecture by Perel'man. His rejection of the Fields medal in the course of that congress captured media attention, which gave great visibility to the news and indirectly to mathematics. You see, I think that these two events have had a real influence on Spanish population, and I think that much of the merit for that goes to the Spanish Mathematical Society and to the many people who worked to reach this point, including Clara Grima, Fernando Blasco, Claudi Alsina and Raúl Ibáñez".

The renewed public image of mathematics in Spain is the result of a careful, prolonged, planned and demanding work by the entire mathematical community. Alsina, Blasco and the others are anything but amateurs chancing it, as Giorgio Vasari describes the architects who built the tower of Pisa in his *Lives of the Most Eminent Painters Sculptors and Architects*. They have instead built a magnificent edifice on a foundation consolidated over the years, improving

[4] "La Ventana" is the afternoon radio programme of current events, interviews and humour currently most followed in Spain, hosted by Carles Francino on Cadena SER.

the quality of communication on all levels: among peers, between experts and non-experts, between researchers and the public and so on. Furthermore, popular mathematics has played a decisive role in this change in attitude in Spanish society. And yet, it is not uncommon to hear the question, even from colleagues: "Why do I have to spend my time doing outreach, popular science or, in a broader sense, communication?"

I turn the question to Eduardo, who begins by saying: "It's a big question". Then he adds: "There are many reasons for doing so. One, I believe, is that society has the right to understand what society itself is carrying out in scientific research. As science is part of culture, we have the right to know our own culture and to grow as an aware society. Then, we have the right to know what they are doing with our money. Are you working on public or private funds? What are you doing with them? Are you solving someone else's problems? Finally, we have the inner need to communicate, and this is good because it allows us to share with other people who we are and what we are doing. Sometimes, I see the communication of science and education, each on its own level, like the work of the ancient story-tellers before writing asserted itself. In the tribes or communities there were people who helped others understand 'who we are' and 'what the world in which we live is like' and these people had the secret mission of transmitting the knowledge of the tribe. Now this is done in school by teachers and outside of it by science communicators, because we need to transmit this knowledge about ourselves and the world in which we live to other people, so that society as a whole grows with its knowledge and encourages us to continue with our work. Obviously, I'm not saying everyone should do it. Not every scientist must be a communicator of science, but I think it is important that science, even if perhaps not all of it, should be communicated to society".

I think there's another reason too: we have a great responsibility, as citizens, since today science, mathematics and its algorithms are governing many aspects of our lives without our being at all aware of it. We therefore have the responsibility to communicate to people, because an informed society is freer and less susceptible to manipulation based on science or on the interpretations of science. A duly informed society, as well as a critical citizen, is less vulnerable to this kind of misunderstanding or deception, whether these misunderstandings are self-serving or not. Especially if algorithms are governing our lives, we want to understand how they work; we want transparency on how they are used. In this direction, scientists can do a lot to help society.

The lively atmosphere of the place, which has filled up since we sat down, distracts us for a moment. While Eduardo is talking with Silvia, I reflect on his way of communicating. He talks clearly and slowly, measuring every word and every silence to the millimetre. He knows how to make sure

Fig. 3 Eduardo Cabezón with the Weaire–Phelan structure during the 2013 FameLab finals

that those who are listening to him do not turn away their attention. It is easy to empathise with him, especially since he always looks you in the eyes when he speaks to you. No doubt, much depends on the fact that before being a mathematician Eduardo was a story-teller. He was just a teenager when his love for theatre and performance blossomed. "It was the 1980s. I started telling stories to both children and adults. Then, around 1990, I started giving shows in cafés, theatres, even nightclubs, and I continued for many years. I think that my vocation for communication comes from that." Later, he founded the project named "Big Van Ciencia: Científicos sobre Ruedas",[5] a group of scientific monologists and actors committed to spreading love for science, and his two vocations came together: it is a project that is enjoying an enormous success in Spain and beyond. I ask to know more about it.

"There is a contest for scientific monologues called 'FameLab',[6] which also takes place in Italy, and whose international finals take place during the Cheltenham Science Festival in the United Kingdom. In 2013 Spain participated in the contest for the first time and I was there as one of the members of 'Big Van' (Fig. 3). Those who participated in the Spanish semifinals had never seen a scientific monologue before. When we saw this, we liked it and we said: 'Wow! We like this format! Why do not we take it around in theatres, bars and everywhere else?' That was how the adventure began. If I remember correctly, the finals in Spain were

[5] http://www.bigvanciencia.com/.

[6] "FameLab" is a competition for scientific monologues launched in 2005 within the Cheltenham Science Festival, in collaboration with NESTA, to find and train scientists and engineers who have a predisposition in communicating science to the general public. In 2007, thanks to the collaboration with the British Council, it became international and ended up reaching more than 30 nations in the world (it arrived in Italy in 2013). It takes the form of a talent show during which the finalists have three minutes to offer the audience a scientific topic of interest that will then be evaluated by a jury consisting of experts from the world of science and communication.

in May and already on the first of June we were giving a show in a café. We won that edition and, since then, we have grown a lot, especially in Latin America. To date, we have also started some European research projects to study how to improve science communication through performance and how this format could stimulate scientific vocation in students. One of these, called 'Perform', is inserted inside Horizon 2020, in collaboration with some European partners. In addition, we are organising training courses for teachers, summer schools and science communication workshops to share the experience we have gained over the last few years with hundreds of shows around Spain, from prisons up to performing in front of the King and the Queen. Basically, everywhere."

In the "Big Van" group different skills coexist, but the phases of writing a monologue are well established. Initially, each person, according to their discipline, writes their own "piece" on a specific theme which is about current events or has some interest for the public. Once it is drafted, they present it to the group. A control phase follows: first the correctness of the content is checked, then everyone says his monologue in front of the others. This last aspect is important, since everyone becomes a tester for the others. For instance, when a biology monologue is done, Eduardo and the other non-biologists act as the general public and so on. At this point, if someone expresses some doubt or says he has not understood anything, they work together to double-check the various parts of the monologue, fixing or changing them. Once the piece is roughed out, they work on the jokes, the acting and so on. This perfect assembly line produces high-quality products.

I ask Eduardo: "How important is interdisciplinarity in a group like this?"

"For the show, it's fantastic!", he replies. "It's great, because people can see how diverse science is and some may be attracted to some of the themes. Very rarely someone is not. We realise this because at the end of the show we always provide a time for questions and answers, and people can ask anything about the topics covered, the monologue or science in general. That's where you realise that people want to know. They ask a lot of things. Some are really weird, for which we do not even have an answer; others are very technical or something. For instance, in one of the last shows I was asked this question: 'How did the Romans multiply with Roman numerals?' My answer was that I did not know, I would look for the answer later, but I thought this was the reason why the Roman Empire fell apart!"

While it is essential to connect with the public using humour, this is not the only resource. An effective scientific monologue must have contents that are relevant and not just be about trivial things. It must be clear but can make use of puns, plays on words, and allusions to what is happening at the time of performance or in society, and all of this is combined with the charisma of the actor. In short, it must be able to make people laugh and reflect at the same time. But what is needed to achieve this purpose?

"My mantra is: at the top of the hierarchy there are contents, with the audience at the centre of the attention. The monologue must connect these two with humour in the form of entertainment", Eduardo explains, visibly involved in the topic of the discussion. "Sometimes, the mistake we make as scientists is that we clearly understand that at the top of the hierarchy there are contents, but too often the focus is on ourselves. There is a sort of Copernican shift—I do not know how to explain it—in which the sun is the audience. That contents are at the top of the hierarchy means that, whatever my communication skills, everything must be at the service of the contents. When I use a joke, or repeat something, or decide the narrative structure of my monologue, it is always done to make the contents more understandable. So, when there is a difficult point, it is there that I have to deploy more resources, such as humour. I have a friend who is a computer scientist and is often invited to speak at scientific conferences. Whenever he is in the middle of his talk, he shows a picture of himself on vacation. After a series of boring slides, he inserts this slide with a photo of himself in the pool or at the beach and says: 'Oh sorry... there must be a mistake'. And immediately afterwards there is the theorem or the main point of his talk, because at that point he has everyone's attention. This is a resource in action at the service of the content".

There are two ways to make people genuinely passionate about what they are watching or listening to. "One way is what I call 'move the topic towards the audience", Eduardo goes on like a river in flood. "Find something in the subject you are proposing that can touch what is already affecting your audience. Love, for instance. The other way is 'move the audience towards your topic', that is, tell a story or whatever you want, provided that at some point the listener asks himself a question. They were not interested in the beginning, but now they are, and then you say, 'Follow me, now we are coming to the answer of the question'. It is a bit more complicated and more unusual, but it works. I did it in a TED Talk in Argentina called 'El poder de las historias' (The power of stories).[7] I told the story of Galois. I started the story by saying: 'This 20-year old boy was scared. He was sure he would die the next day. He wrote about mathematics all night long and 200 years later every mathematician learns the things that this frightened boy wrote on the last night of his life'. At this point, everyone wants to know what he did. What was he hiding? They were not interested in group theory before they came in, but now when they hear about this dying boy and the fact that 200 years later every

[7] https://youtu.be/mWFqtxI4NKM.

mathematician in the world needs to know what he wrote in those sheets, they all ask: 'Ok, what did he do? Tell me. Now I want to know!'"

In 1981, the German psychologist Friedemann Schulz von Thun of the University of Hamburg proposed a model of interpersonal communication that envisions four different dimensions in the so-called communication square: the content (what it is all about), the relationship (how the speaker defines their relations with us), the self-revelation (the speaker, consciously or not, reveals something of themselves) and the appeal (what the speaker, explicitly or implicitly, asks the listener to do, say, think). Those who communicate must have a good knowledge of and familiarity with these mechanisms, which involve three different types of communication: the verbal, which occurs through the use of both written and oral language; the non-verbal, which takes place without the use of words through different channels such as facial expressions, looks, gestures, postures; and the paraverbal, which concerns the tone, volume and rhythm of the voice, as well as the use of pauses. The more these tools are mastered, the more effective communication is. Moreover, from this and the previous reflections, it emerges that there is no "algorithm" of communication that is good for everyone, since every level of knowledge has its own rules. "If there were one, it would be NP-complete", says Eduardo with a smile. "There is a high level of complexity and I do not think there is a algorithm that is good for everyone. I see it in the work I carry out both in terms of research and in terms of popular maths. I see myself working in the communication of mathematics as someone who addresses the public in general, so that they can begin to love mathematics in a playful way, for its interests, and then become interested in what other mathematics communicators are doing with great books or more demanding lectures. Some time ago, someone told me: 'After seeing your talk in which you spoke about Alan Turing, I went to a bookshop and bought the biography of Turing'. So there might be an interaction between these levels and I see myself as a sort of bridge, a springboard to jump to something else. There is excellent mathematical communication out there. It is only necessary to stimulate interest."

"I know that my voice has got nothing to do with it, but here are the desserts and they are delicious!" Here we are: a practical example of how to stimulate interest. When dessert is finished, Silvia hints to me that there is little time left, but Eduardo wants to continue. I take this opportunity to ask him to draw a comparison between communicating mathematics and communicating science. "An analogy is that they are both communication of knowledge, of a certain type of knowledge with a structure, a method and an assessment made by experts outside the world, seen as super-beings. Moreover, both have important applications for solving the problems we face in real life. One difference, on the other hand, is that any science or technology we need has mathematics at its core. Even if it cannot be immediately seen how computer algebra connects to computer science or to my form of mathematics communication, mathematics lies hidden behind. But this is not clear to everyone. Finally, another difference is that mathematics has its own language and is food for the mind, food for the brain, while science is experimental, more practical." This last difference can be the reason why many people have a disaffection towards mathematics, with which they form personal stories of suffering and rejection, that they do not have with other sciences. They even come to hate mathematics because the only experience they have had with it was at school and in most cases it is not a pleasant memory. "And it is a pity, it is a shame. Another analogy is that we want to communicate mathematics and science not only because they are useful, but because we love to learn more, we love getting involved in doing things. There is a famous quote by Richard Feynman that refers to physics or the sciences, but it can easily apply to mathematics. He says: 'Physics is like sex: sure, it may give some practical results, but that's not why we do it'. For mathematics it is the same. When I teach, I often talk about this difference; I call it the 'pancreas paradigm'. When your students ask you 'What use is it?', you can answer that 'mathematics is behind everything and you might not use it, but without it our life would be much more complicated; it is doing a lot of things for you'. The same is true for the pancreas. It is doing a lot of things for you and without it your life would be much more complicated. You know this, but you do not devote 5 hours a week to studying the pancreas. Instead, we do with mathematics."

No one would find it reasonable to devote hours of study to the pancreas at school, and no one would think that the time devoted to the pancreas could be interesting and enjoyable. In short, that is just an excuse to try to make the time devoted to mathematics bearable. Let me be clear that I am not saying that we should not give importance to mathematics in schools, let alone that it cannot be interesting or even exciting and fun. I am just saying that these arguments are not enough to attract attention and to make the importance of the study of mathematics fully understood. There must be more.

"Much more. That answer is right, it's true, but it's not enough. I believe we should move on to the paradigm that I call the 'Kamasutra paradigm'. This paradigm holds that each of us finds the Kamasutra attractive, seductive and intriguing, even if we have never read it. Nobody has read it. But the feeling people have when they talk about Kamasutra is that 'the better you know it, the more pleasure you have'. You see, I think this should be the idea we should have in education, especially in teaching mathematics. Those who know more, enjoy it more. They are able to enjoy the things they would not be able to enjoy without this knowledge. The

Fig. 4 Cabezón at the TEDxRíodelaPlata in Buenos Aires in 2014

joy of mathematics can be very powerful, both in education and in communication. I often receive comments from readers or from people who watch my videos telling me 'I still do not understand, but I like it!', which means 'I want to know more and I'll work hard to learn more'. This is my goal when I communicate."

There is another famous TEDx talk by Eduardo, given in October 2014 in Buenos Aires, entitled "Las matematicas son para siempre" (Fig. 4).[8] The video has reached over one million views. In less than 10 min, it show the beauty of mathematics and sends a message to the audience: "Mathematics is forever, not diamonds". It is a concrete example of how to make communication and how to properly use all available resources. It is a monologue with lofty contents, but which starts from the audience. "Actually, the story of that talk starts long ago", Eduardo explains. "It started with a workshop on tessellations for high school students. They were enthusiastic. I found this example of manipulating tiles to fill the plane and then similarly in space to be very significant, and I considered it especially interesting to try to understand what the best way to do it might be. It gives you a deep insight into a very important topic in mathematics, such as the difference between a conjecture and a theorem: a proven result that is the basis for further mathematics. Later I was asked to give a talk on mathematics for TED in Argentina and I thought that this is a fundamental point and people do not normally realise how much it is so. It also has something that connects in many ways to what we are deep inside as human beings. We want to be indelible, in some way, and there is nothing more enduring than mathematics. I began to reflect on what theory I would like to be permanent and I was thinking about fame, art. Then, I told myself: why not love. It is something we want to continue with us, something fundamental for man. So, I set out to find something that was deep within mathematics and connected with something very deep in humans, and I realised it was a pleasant connection."

The bill arrives. We allow ourselves a few minutes more. Communicating is expensive and requires funding, but unlike at the restaurant, the bill is presented before you even sit down at the table. Without funds, no project starts, regardless of whether the idea is good or not. Most Italian universities still invest little in communication and popularisation projects, despite the precise input received with the establishment in Italy of the *Terza Missione*.[9] The schools, for their part, have at their disposal ridiculously low levels of funding for activities of this type and the municipalities, as well as the regions, prefer to use funds in other areas. In contrast, in recent years Europe has allocated substantial funds by creating specific funding items for communication and dissemination projects, but it is not easy to access them. Silvia and I have shared the experience of "Unicam Science Outreach", an interdisciplinary research group on science communication funded by the University of Camerino over the last 2 years, and we have experienced first-hand how important it is to have funds to support communication activities. These have allowed us to carry out significant research projects, to experiment with innovative formats and approaches to scientific communication and to acquire the skills and abilities that are necessary in the field. We could not have achieved these goals without a solid base, both economic and of shared knowledge. In agreement with Silvia, I ask Eduardo: "How do you finance your activities?" "I'm rich!", he replies, bursting into laughter and infecting us too.

He regains his composure and starts again: "In many ways, actually. One is this: since we do theatre shows, people have to pay a ticket like for any other kind of show in a theatre. At other times, some universities or museums include the cost of the show in entry tickets. Other times the performance is free, perhaps because there is a large company that is paying thousands of euros for the event. But there are also small schools that cannot afford to pay. So, we let the 'rich' pay for their events and for others. Then, there's my case. I have a job as a university professor and I can afford to go to some places asking just to be reimbursed for expenses: I can afford it. Of course, if I relied only on my work as a scientific communicator, it would be more complicated, but sometimes you can still find other ways to finance activities, such as joining European funding projects [such as 'Perform']".

Time is running out, but I have one last curiosity to satisfy before saying goodbye. Eduardo has a degree in theology too. I am fascinated by this aspect because mathematics

[8] https://youtu.be/jej8qlzlAGw.

[9] Translator's note: Literally "Third Mission", it denotes the universities' activities in direct contact with the society at large, in parallel with their two traditional missions of teaching and research.

and religion are often perceived as separate worlds, in sharp contrast. Religion assumes an act of faith without the necessity of having to prove anything, whereas in mathematics we have to prove everything before assuming it as truth. But, looking at the past, many great mathematicians—such as Pascal, Mersenne, Barrow, Craig and Grothendieck, to name only a few—have had close ties to religion. Attracted by this dilemma, I ask: "Is there a way to reconcile the two worlds?" Eduardo reflects on it, as he collects his things before heading for the exit.

"I do not think that conceptually mathematics and religion are the same thing. I think they are two different realms, but often some reflections, some facts of life... I think there are some common points. One of these is what people can do together in a community. Sometimes the good part of religion is exactly this: it unites people in a community just like mathematics does. The bad part is that this community starts fighting against other communities. I am convinced that there are things that are more interesting than this in religion. The fact remains that mathematics and theology have no topics in common, except for the search for truth. Perhaps there is some connection, if you think that a great logician like Gödel tried to prove the existence of God. I believe that a point of contact between science and religion could be not what we know and how we express it, but what we do not know. It is something that connects us more deeply. Science, like religion, is about the construction of a community and I believe that the need to communicate comes precisely from here. There is a good book by Jorge Wagensberg entitled *El pensador intruso*, an interdisciplinary book on thought.[10] He was a man who always tried to define things. In the book he states that there are three ways of thinking or facing the world: the scientific approach, the artistic approach and faith, and he holds the thesis that most of the actual expressions of thought in human history have been a mixture of these three. Science tends to be universal: it is the same for everyone and it is the knowledge we proceed to share. On the other hand, the artistic point of view is personal, in the sense that I, the artist, share my life experience with you so that you can improve yours. This is what an artist does. Faith, finally, is something in which you do not do the choosing. This is my vision of the world; if you are not in this worldview, you do not have to come with me. You can feel free to go somewhere else", he concludes and, without losing his humour, he adds with a smile: "It's an interesting topic for a conversation at a wedding". In the communication of mathematics it is different. Sooner or later, the time comes when people must trust what you say. "Yes, but they can check later. At a talk in which I spoke about Alan Turing's 'halting problem'[11] and its undecidability, I had to say 'you have to believe me', but I also invited the audience to read Turing's paper to check if what I had said was true. After all, Alan Turing is readable."

We are now at the restaurant's door when I hear the waitress tell Silvia: "From what little I heard, I understand that the gentleman must be someone important". And then, addressing Eduardo, with her contagious charm: "You know, I work and that's it, understand?" In general hilarity, we say goodbye to Silvia and I walk Eduardo to the place of his talk. We continue to talk during the walk on the Lungarno to the Department of Agricultural, Food and Agri-environmental Sciences. Eduardo explains broadly what he will say in the talk he will be giving shortly to a group of doctoral students, and in the talk on the following day that is open to the public. I take this opportunity to ask him what his future plans are.

"Writing a book on female mathematicians. In the mathematical community there is still today a certain diffidence with regard to them, even though much is changing. Just recall the chilling joke attributed to Hermann Weyl, the pupil of Hilbert: 'There are only two female mathematicians in history, Sofia Kovalevskaya and Emmy Noether: the first was not a mathematician, the second was not a woman'. This is one of the most wrong things that can be said. It is horrible. So it would be very good to write a book on female mathematicians to reflect on what was lost by excluding them from mathematics. Then, we are setting up a new show with the 'Big Van' group, which is a kind of round table on humour during which, starting from absurd and ridiculous questions, we begin to talk with experts about the issues that are chosen each time. An original approach to acquire knowledge starting from absurd questions. Finally, I am continuing my research and I currently have a PhD student with whom we are entering a new field of research. Ah, I forgot... the proof of the Riemann hypothesis" and we burst out laughing. "Nay, P vs NP!" His affability makes everything seem so simple. It does not even seem that we have met just three hours ago. But basically this is the greatness of a man. Saint Augustine said: "If you wish to be great, begin from the least. You are thinking to construct some mighty fabric in height; first think of the foundation of humility". Eduardo is just like that.

In 1201 Leonardo da Pisa, known as Fibonacci, wrote a book that would be a breakthrough in computing methods, with practical as well as scientific advantages, simplifying

[10] Jorge Wagensberg Lubinski (1948–2018) was an award-winning Catalan teacher, researcher and writer, as well as one of the most famous scientific popularisers in Spain. The book is *El pensador intruso: el espíritu interdisciplinario en el mapa del conocimiento* (Tusquets Editores, Barcelona 2013).

[11] The halting problem asks whether it is always possible, given an algorithm and a given finite input, to establish whether that algorithm terminates or keeps running indefinitely.

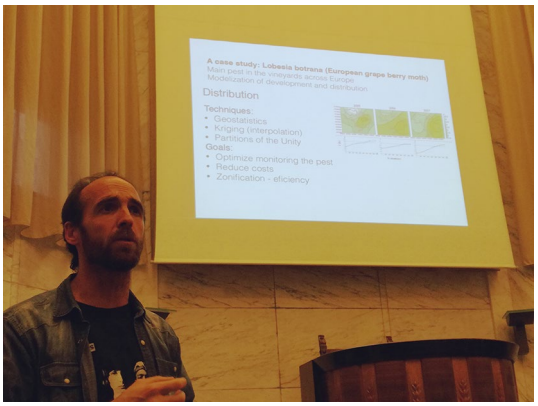

Fig. 5 Cabezón during the seminar "The new mathematics of agriculture" for postgraduate students held in the Aula Magna of the Department of Agricultural, Food and Agri-environmental Sciences of the University of Pisa

the work of merchants and accountants. This brought about a cultural revolution made of numbers that is still among us; a similar revolution was brought about by the birth of personal computers in the 1980s. Eduardo's work, like that of many others, is opening new avenues in the communication of mathematics and science towards fascinating and unexplored horizons, but this requires time, passion, study and spaces where it is possible to experiment innovative and original approaches. Maybe we have to put fear aside and try to draw closer in a way that is different from what we are used to. For instance, not using mathematics and mathematicians to make people laugh, but using humour and laughter to teach science. It could be a real paradigm shift, a genuine revolution intended not to supplant the mathematical structure, but to provide another entry into that mathematical world that is too often far from everyday life.

I sit in the third row in the Aula Magna and leave the stage to Eduardo (Fig. 5). I enjoy his talk and verify firsthand the truth of all that emerged in the three hours we spent together. Every gesture, every word, every pause comes at the right time. Applause. Curtain.

Appendix: Eduardo Sáenz de Cabezón.

Eduardo Sáenz de Cabezón was born on 24 June 1972 in Logroño, Spain. In 1996 he graduated in Theology and for the next 9 years he taught at the secondary school IES Duques de Nájera in his hometown. In the meantime, he earned a degree in mathematics and in 2001 became a professor of Computer Languages and Systems at the Department of Mathematics and Computing of the University of La Rioja in Logroño. In 2008 he obtained a doctorate in Computational Algebra and continued his research in the area of the homology of monomial ideals, algorithms and applications. Together with Professor Henry Wynn of the London School of Economics, he developed the area of algebraic reliability and carried out studies and research in algebraic statistics and mathematical models for integrated pest control. He also collaborates with the research group at the University of Genoa that is developing the CoCoA computer algebra system.

He works in the communication and dissemination of mathematics at different levels: university, high school, with the general public and the media. In 2013 he won the FameLab competition for scientific monologues and represented Spain at the international final that takes place every year within the Cheltenham Science Festival in the United Kingdom. The following year he also won the Fundación Aquae competition. In the same year he founded the group of scientific monologists "Big Van: Científicos sobre Ruedas", which has staged more than 500 performances in Spain and Latin America. He also collaborates as guest, expert or author with several Spanish media: television (*Órbita Laika, La aventura del saber, TIPS*); radio (*SER, Onda Cero, RNE*); and the press (*Yorokobu, El Confidencial*). He is also author and host on the "Derivando" YouTube channel on mathematics, produced by Zeppelin-Endemol.

He was featured in the special twentieth-anniversary issue of *Quo Magazine* as one of the 101 most creative and brilliant minds in Spain. He is the author of *Inteligencia matemática. Descubre al matemático que llevas dentro* (Plataforma Editorial, 2016). He is currently engaged in organising courses and workshops on communication and dissemination of mathematics for teachers, researchers and journalists in Argentina, Spain, Mexico and Uruguay.

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Andrea Capozucca earned his degree in mathematics at the University of Camerino, and holds a Ph.D. in complexity science from the University of Urbino; he teaches mathematics and physics at the Liceo "Giacomo Leopardi" in Recanati. He presently has a grant from the University of Urbino for scientific and support activities and is a lecturer at the School of Economics and Management of the University Carlo Cattaneo. He has been working for more than ten years in the field of science outreach and public engagement with science, mathematics and

technology. He is a member of the International Coalition of STEM Educators coordinated by Chris Brownell of Fresno Pacific University, and since 2018 is a member of the Scientific board of the Interuniversity Research Center for the Communication and Informal Learning of Mathematics "matematita". He has created and organised various events, including "Matematica sotto l'ombrellone", "Matematica Informale: aperitivi con la scienza", "Math&Co: la matematica tra arte e gioco", "VereMath Street", "Scienza in contrada" and "Scienza in vacanza". Since 2017 he is the scientific director of "FermHAmente", the science festival in Fermo (Ascoli Piceno, Italy). He is co-author, with Barbara Cerquetti, of *Il tranello e la soluzione matematica* (Giaconi Editore, 2016) and author of *Comunicare la matematica* (Egea, 2018).