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REVOLT PIMENOV TAUGHT US HOW TO BE SCIENTISTS

Vladik Kreinovich
Ph.D. (Phys.-Math.), Professor, e-mail: vladik@utep.edu

University of Texas at El Paso, El Paso, Texas 79968, USA

Abstract. In 2021, we are celebrating the 90th birthday of Revolt Pimenov, a specialist in space-time geometry. He was my teacher. In this article, I am trying to summarize what he taught to his students.

Keywords: how to attract students, how to write papers, how to select a research problem.

1. What This Article Is About

This year, we celebrate 90th birthday of Revolt Ivanovich Pimenov, a researcher who pioneered new directions in space-time geometry. I was lucky to learn from him:

- I attended his seminar in 1969-70, when I was a freshman student at St. Petersburg University,
- I spent a semester working with him in Syktyvkar, Komi Republic, his place of exile (for samizdat) – as an official practice semester sponsored by my university,
- I had many discussions with him in 1974 when we both attended the First National Conference on Chronogeometry in Novosibirsk in 1974, and
- we exchanged a lot of letters.

He was one of my teachers, one of those who taught me how to do science – and, more generally, how to live. In this article, I will summarize what he taught us – me and other students of his.

2. How to Attract Students to Do Science

At St. Petersburg University, we had numerous weekly research seminars led by leading professors, seminars that were open to all the students. Some seminars studied a certain topic in details week after week, but many other seminars just had different talks every week – so that you could skip one week if you are out of town or otherwise busy and still understand what is discussed next week.

This was one of the main duties of the seminar organizer(s) – to make sure that as much as possible is understandable to students – and students were strongly encouraged to ask questions if something was not clear. I remember at some point Pimenov introduced me to one of his colleagues by saying that Vladik is very good student: he asks many questions at the seminar.

Sometimes, a speaker would dismiss a question as childish and/or naive, but in this case, the seminar leader usually jumped in and forced the speaker to reply.

All our professors highly recommended us, freshman students, to attend one or more of these seminars, so that later on, when the decision would need to be made to specialize, we would have a good idea of what the choice are. I attended three seminars: on logic and constructive mathematics, on game theory, and Pimenov's seminar on space-time geometry – largely based on his then-published book [5]. All three were interesting seminars, and I especially liked Pimenov's seminar – since there, in addition to mathematicians, he also invited physicists who often provided a different view of problems related to space-time.

A seminar organizer would approach new students attending the seminar, ask about their specific interests and their level of knowledge – and then offer a new paper (or, sometimes a book) to review at the seminar (with the organizer's help, of course). To me, Pimenov suggested that I review a book Space-Time Algebra by David Hestenes [2]. It was an interesting – and still somewhat heretic – approach to describing physics, where the main objects were not, as usual, separately scalars, vectors, tensors, etc., but rather linear combinations of a scalar a, a 4D vector a_i, and antisymmetric tensors a_{ij}, a_{ijk}, and a_{ijkl}, with a multiplication operations similar to 3D vector product. Interestingly, this unusual combination of apples and oranges allows to simplify a description of physical equations – just like the introduction of vectors made the description of Maxwell equations simpler.

This book would probably not impress a physicist – as I remember, there were no new physical theories, no new results – but as a mathematician, I was impressed. It took me several months to go over this book – with Pimenov's help, and with his help, I presented it at the seminar. I was very much impressed by the fact that I, a freshman student, was able to teach something interesting to renowned professors. For many years, I kept the flier advertising my talk as a souvenir, and after my talk, Pimenov have me a present: Hestenes's book. You will never forget your first seminar talk – he said – just like you never forget your first serious love. And so it was.

Later, he gave me a problem to think about – how to embed a kinematic space (his model of space-time as an ordered set) into a lattice kinematic space, following the known result that every ordered set can be embedded in a lattice; see, e.g., [1]. I was hooked, I thought about it all the time, always carried with me a piece of paper to draw possible spaces and embeddings. This was a good way to spend time when standing in lines – in a cafeteria, in a store, in a library. I befriended another student whom I met at the library and who recognized by my drawings that I was interested in lattices. Once, when making these drawing in a bus, I almost got into trouble since one of the passengers thought that I am a spy drawing the plan of the city; luckily, it was no longer Stalin's time (under Stalin, such accusations were taken more seriously), so other passengers simply laughed at this suggestion – especially since this did not make sense when one could easily buy a map of St. Petersburg.

By the way, I never solved this problem, but I got hooked on research anyway.

3. How to Select a Problem to Solve

It is important to have a good supply of open problems, so that:

- you yourself can solve some of them, and
- you can offer to every student of yours a problem that best fits her/her interests.

Sometimes, one gets a genius idea and comes up with a great problem, but such events are rare, so what should we do? Here, Pimenov had many ways to find problems.

Find related ideas in other sciences and try to relate them. This is very natural for space-time geometry – which is naturally related to space-time physics. Pimenov had a somewhat naive (but maybe correct) belief that many problems of physics can be solved if we make physics completely mathematically precise – and not filled with intuitions as it is now. This was the main motivation for his work in the first place, this is why he so enthusiastically invited physicists to his seminar – and was especially interested in their challenging open problems.

Sometimes, he would ask them a lot of question about differentiability etc., questions that physicists considered nitpicking, but which to him were important, since he wanted to understand everything in precise mathematical terms. He bombarded Penrose and Hawking, who just published what was supposed to be a theorem that a singularity is inevitable in General Relativity, with these types of question until they stopped answering.

He also believed that we should be able to formalize physicists' intuitive reasoning – he thought that Zadeh's fuzzy logic [15], which at that time, few people took seriously, is an important step in this direction, but that to truly formalize physics, we need to got beyond Zadeh's idea of degrees of certainty being numbers from the interval $[0,1]$ – Pimenov thought that a more general approach, similar to his kinematic spaces, would be more adequate.

Pimenov also wanted to find connections the other way around – he was always curious about possible observable consequences of his non-standard space-time models.

It was not just relation to physics: he saw many ideas about space-time in philosophy, and was eager to try to formalize them. To tell the truth, while I appreciated and shared his enthusiasm for physics, at that time, I viewed philosophy as mostly nonsense – following the famous Russian psychologist Ivan Pavlov who cited Hegel's writing as an example of senseless psychotic mumblings. Pimenov tried to impress me by citing Hegel's phrase that the Great Square has no vertices – which he interpreted as meaning that in the limit, the larger and larger square becomes simply a plane, all vertices disappear. However, I was – at that time – not convinced.

See if results from related areas can be extended to your area of interest. Kinematic spaces are a particular case of ordered sets – and they also have a natural topology. So, a natural idea is to take some results about ordered sets or about topological spaces and see if a similar result can be formulated about kinematic spaces.

I have already mentioned the lattice problem that I was unable to solve. There were many others: one of them (which I did solve) was to extend the theorem that under reasonable conditions, topological spaces can be metrized, to prove that under similar conditions, every kinematic space would have a "kinematic metric" – a natural generalization of geodesic-based proper time between events as defined in relativity theory. He also asked a now-renowned topologist Yakov Eliashberg (who at that time worked in Syktyvkar) how to generalize homotopy theory to cases when we limit ourselves only to time-like curves connecting two points (or only to space-like curves).

Which properties are preserved under constructions. In every theory, there are basic objects, and there are constructions that combine them (and/or objects from other theories) into new objects. For example, in space-time geometry, we can naturally define Cartesian product of two spaces – or we can generalize the usual causality relation of special relativity to the case when the proper space is not 3D Euclidean but a general metric space. A natural question is, e.g., when does the Cartesian product have the given property?

For example, is the Cartesian product of any number of separable kinematic spaces always separable? To this, I found a counterexample – that the Cartesian product of countably many copies of the real line is a non-separable kinematic space.

4. How to Write Papers

A paper must be interesting to read. Once the result is obtained and the proof is written down and checked, now comes the need to prepare it for publication. When I started working with Pimenov, I followed the boring style, with no motivations. I was also writing poems and short stores which I was glad to share with my teacher. Proofs came tough, I was very proud of them, while stories came naturally. I was somewhat shocked when Pimenov said that my short story parodying our then-naive Zionism – Life and Adventures of Boris Haimovich in a 12-Dimensional Jewish State – he liked much more than more than 100 pages of my complex proofs.

His comments reminded me of how Nikolai Vorobiev, the organizer of a game theory seminar that I also attended, taught us how not to write: he brought, to seminar, a paper on game theory that was written with no motivations at all, it started with "Let A be a σ-algebra". After having attended several talks at his seminar, we understood very well that this was indeed a very important result with great consequences for game theory, but one would never guess it from the way the paper was written.

But too colloquial is also not good. When I was in Syktyvkar, Pimenov presented a cycle of lectures on space-time geometry. Several of us tried to write them down, he also recorded it on a tape recorded, with a purpose of later forming a textbook – this was how many textbooks were written in those days and probably how many textbooks are written now. His lectures were brilliant and exciting, but, to our big surprise, when we literally wrote down word-by-word, it did not look so good: some phrases were not finished, there was a lot of repetition. We learned that we need to edit, and we learned how to edit, and it all helped us write our own papers.

5. How to Self-Gauge the Quality of Your Own Results

This is difficult. Every time you get a new result – especially if it was a challenge – you like it. But this does not mean that others will like it. How do you guage the result's quality? This is one of the things that Pimenov taught us: that there are three reasons why results are valued more by others.

First reason: general results are valued more. A counterexample is cute, but a general result is better. Pimenov did not even suggest that I publish my result about Cartesian products – but he send my metrization paper to A. D. Alexandrov, the country's leading specialist in space-time geometry, to publish in Doklady – one of the top journals [3]. This result became the most praised part of my PhD dissertation [4].

Second reason: somewhat famous formulated the problem. If you yourself formulated the problem – or your not-well-known advisor – why would anyone be excited about its solution? On the other hand, if someone famous formulated it, it is a different story. For example, as it turned out, the question about metrization of space-time models (at that time, they were not yet called kinematic spaces) was first formulated by the famous topologist Urysohn, and later studied by a renowned geometer Vadim Efremovich.

Third reason: when you completely solve the problem. For example, according to Pimenov, if I found, for each of the important properties of kinematic spaces, necessary and sufficient conditions when a Cartesian product would have this property, this would have been a good paper. On the other hand, a partial result is not yet a good paper.

6. How to Live

Attitude to scientists: respect and adore (but it is OK to also make fun). Pimenov had a great respect to people who had interesting results, even though some of them not always behaved in the most ethical way. Even foreign scientists would sometimes not cite known results of others – while they have read the others' papers and used their ideas.

In particular, he was very tolerant towards A. D. Alexandrov, even though A. D. was a very emotional person, ready to explode and to be not very polite with others, and not only with the ones who made him mad.

But making fun sometimes is OK. Pimenov reminded me that even in the ancient Rome, when the Emperor had a triumphal ride through the city, the best comedian was following him by foot parodying his pompousness.

Attitude to bosses: healthy scepticism and a need to compromise. Pimenov was always sceptical about non-scientist bosses, he considered it healthy to assume that they have other unspoken motives – be it careerism or fear of their own bosses or something even worse. And sometimes, he turned out to be right.

On the other hand, he taught us to compromise. This was unusual to hear from an active defender of human rights who was exiled for this defense, but what he said made sense: if one have a God's spark to be a scientist, this should be your main goal, everything else in a distraction preventing you from doing science. To me, he said that if I felt that I would rather be a Zionist story writer, I should emigrate to Israel and forget about science. But if I decide to do science, then I should not waste my efforts on such stories. He himself felt that in him, there were sparks both of a scientists and of a human rights fighter. He loves and adored many revolutionaries of the past, but he gave an example of Taras Shevchenko, the great Ukrainian poet who was clearly not a born revolutionary. All Ukrainians and all Russians loved (and still love) many of his poems, we all sang beautiful songs made when his poems was put on music. But Shevchenko's life was ruined when he wrote a poem insulting the Tsar's family and was made a soldier without the right to write anything.

In this advice to compromise, he was similar to my own Dad – who also taught me that going with sabers against tanks is not the smartest idea – you die and the tanks are not hurt at all. And by the way, it was similar to the advice that we learned from studying Lenin's works: it may be a surprise who have not studied his works, but he often was on the side of the compromise – and this was one of the reasons why he was so successful.

7. Conclusions

Do I agree with all this advice? Not necessarily, but now, after several decades, I appreciate Pimenov's advice much more than I did then. So maybe this advice will help others as well. And maybe those whom his advice helped will remember Pimenov by – in the words of Shevchenko – "nezlym tihim slovom", by a few kind and quiet words.

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РЕВОЛЬТ ПИМЕНОВ Н УЧИЛ Н С БЫТЬ УЧЕНЫМИ

В. Крейнович
к.ф.-м.н., профессор, e-mail: vladik@utep.edu

Техасский университет в Эл Пасо, США

Аннотация. В 2021 году мы отмечем 90-летие Револьта Пименова, специалиста по геометрии пространства-времени. Он был моим учителем. В этой статье я пытаюсь обобщить то, чему он научил своих учеников.

Ключевые слова: как привлечь студентов, как писать статьи, как выбрать исследовательскую задачу.

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