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Teaching statement

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1. Teaching preferences

My research interests in *economic design, game theory, and their algorithmic aspects* and my *interdisciplinary background* determine my teaching preferences and my teaching style. Ideally, I would like to teach advanced courses covering a broad range of topics from these fields and demonstrating how similar economic and mathematic ideas work in seemingly different contexts.

- **Modern trends in economic design.** A course on economic design may include fair division, information design, social choice, auctions, matching markets, algorithmic issues, and real-life applications. Among these topics, I am especially interested in fair division and information design.

  Methodologically, the critical role in such a course is to be played by recent revolutionary ideas that allow avoiding classical impossibility results (e.g. the Gibbard–Satterthwaite theorem) and help designers making concrete recommendations relevant for practitioners. These ideas involve the non-classical approach to evaluation of mechanism's performance (average-case analysis instead of worst-case, evaluating trade-offs between objectives by their quantitative relaxation), the robustness of a mechanism to modeling assumptions, complexity issues (small message spaces, algorithmic complexity, sample complexity).
- **Game theory: information & dynamics & inefficiency.** I can teach advanced courses including both strategic and cooperative approaches. My favorite topics are: Bayesian games and asymmetric information, multistage interactions, inefficiency of Nash equilibrium (the price of anarchy), and bargaining.

  The emphasis is to be made on methods rather than on results, including those methods that help to analyze equilibrium behavior in those games that cannot be solved explicitly.

Apart from these courses, I can teach:

- **Math for economists** (and beyond). My topics of special interest are functional and complex analysis, probability, convexity, and their interplay. I also like duality and, especially, structured dual problems such as optimal transportation and maximal flows, which have numerous economic applications.
- **Microeconomics.** An advanced course may include general equilibrium theory, contract theory, and elements of industrial organization.

2. Teaching experience

In 2015-2018, I was involved in regular teaching, students supervision, and popularization of game-theory and economic design in Russia:

- **A course on economic design.** My colleague at HSE St.Petersburg, Alexander Nesterov, and I developed from scratch an introductory course on economic design. We read it together in 2017: both lectures and tutorials. I was responsible for topics of voting, fair division, combinatorial auctions, and complexity issues. Alexander

covered matching markets and classic auction theory. The course was taught in English.

- **Supervision.** I supervised one bachelor and two master theses, and several course works. Topics included: machine-learning for detection of corrupted procurement auctions, adapting competitive equilibrium mechanisms to fair division of indivisible goods? , rent-division mechanisms with shared rooms, statistical properties of reported preferences on Spliddit.org, auctions sniping in online RPG, and others.

  All my students received highest grade (9 or 10 from 10) for their work. The results of an undergraduate student, Yulia Ibragimova, were accepted to the poster session at one of the top conferences on computational social choice, COMSOC 2016.
- **Popularization.**
  - In 2015, I organized an open weekly reading seminar aiming to popularize economic design among researchers and students of St.Petersburg universities, and I gave many talks there. Later this seminar became the research seminar of the Game Theory lab. at HSE St.Petersburg.
  - In 2015-18, I read popular lectures on game theory and economic design to undergrads and gifted secondary-school students.
  - In 2017, I was one of the organizers of the first Russian Game Theory Olympiad. In 2019 and 2020 (the forthcoming edition), I am a member of the program committee.
- **Mini-courses.**
  - "Appeal and challenges of competitive approach to fair resource allocation" (with Vasilis Gkatzelis) at the "De Aequa Divisione" workshop on fair division (LUISS, Rome, 2019).
  - "Modern approaches to fair division" at the workshop "Imperfect Markets: Collusion, Networks, and Crowdfunding" (New Economic School, Moscow, 2017)
- **Tutorials.** In 2013-2014, in parallel to my graduate studies, I taught tutorials at the department of physics of St.Petersburg State University: Analysis 1 and Linear algebra to a group of gifted students (winners of Olympiads in math and physics) and Probability to regular undergrads on theory-track.

3. Teaching philosophy

I was lucky to study, work, and teach in each of the four communities: economists, mathematicians, computer scientists, and physicists. This interdisciplinary experience demonstrated to me how similar or sometimes complementary the ideas from these fields are. However, standard courses in economics, math, or algorithms often fail to present interconnectedness of ideas even within one of the fields. As a result, good specialists are sometimes unaware of simple cross-field connections that may facilitate their study and broaden their views.

I believe that showing how similar ideas originate and work in surprisingly different problems is one of the critical goals of teaching. Understanding the links between various branches of science helps students to look at problems from different angles. Nowadays, when the cross-fertilization between fields is the primary driver of innovations, narrow specialists are no longer competitive. Understanding the unity of ideas can also be incredibly inspirational since different courses are no longer a collection of disjoint facts but a building, which becomes more and more beautiful with each new brick.

Several examples of usually missing connections: in a course of linear algebra I would use the Page-Rank algorithm[1] to illustrate the idea of an eigenvector; discussing the concept of the Nash equilibrium, in addition to standard examples (e.g., the prisoner's dilemma), I would mention routing games and the price of anarchy[2] together with the competitive equilibrium in exchange economies; explaining the basics of general-equilibrium theory I would also explain how the concept of competitive equilibrium applies to economic design;[3] exploring the robustness of Bayesian-equilibrium payoffs with respect to a perturbation of the common prior or a seemingly unrelated question of welfare-maximization in assignment problem, I would connect them both to the problems of optimal transportation and optimal coupling; describing the cooperative approach to bargaining theory and the concept of the core, I would outline their connection to fair division, rationing problems, and equilibria of large markets.

To illustrate this unity of ideas, in my courses, I put emphasis on methods rather than on results, and I present these methods in a tractable and operational way. This helps students to adapt and apply these ideas to their own research agenda and develop their own unique view of the building of science.

[1] A basic ranking algorithm used by web search engines. The relevance of a web-page is defined recursively as the total relevance of web-pages having a hyper-link to it. Thus the vector of relevances is a positive eigenvector of the adjacency matrix of the hyper-links graph.

[2] In my popular lectures on game theory, I have used routing games as the leading motivating example for the Nash equilibrium. In these models, there is a network of roads, where drivers use Google-maps to determine the fastest route given the current traffic situation, i.e., each driver plays the optimal reply to the behavior of others. Such a selfish-routing leads to inefficient equilibrium. This inefficiency can be illustrated by the Braes paradox and quantified in general case by the groundbreaking results of E. Tardos and T. Roughgarden (2000).

[3] H.Varian (1973) introduced the idea of the pseudo-market mechanism to distribute private goods without money transfers; this mechanism outputs the equilibrium allocation in an auxiliary exchange economy, where initially, each agent is endowed with equal division, and then free trade is allowed. The pseudo-market approach has become dominant in the modern fair division, both theoretical and applied.