Teaching Statement

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Teaching Mathematical Structure, Proof, and Application

Teaching Approach

My teaching experience spans three complementary settings: designing advanced lecture series for doctoral students and researchers, teaching mathematical modelling to large engineering cohorts, and supervising students in research projects. Across these settings, my central objective is to help students understand the structure behind a method, see how theoretical results are used, and develop the ability to construct arguments independently.

I have designed syllabi, delivered blackboard lectures, written exercises and examination problems, developed computational material, recorded complete exercise sessions, supported students in person and remotely, and participated in assessment and grading. These experiences have convinced me that effective teaching does not depend on a single technique. It requires coherent course design, adaptation to different backgrounds, and a clear connection between mathematical ideas, computation, and the problems being studied.

Designing Advanced Courses

While a doctoral researcher at KTH Royal Institute of Technology, I was asked by PhD students in electrical engineering to organize an advanced lecture series in statistical machine learning. They wanted a theoretical introduction that would help them read and write research papers rather than only apply algorithms. I designed the syllabus and delivered eighteen one-hour blackboard lectures on statistical learning theory, kernel methods, stochastic and large-scale optimization, bandit problems, and examples connected to my research.

I organized the series around recurring questions in theoretical papers: What is the population objective? What is observed empirically? Which source of randomness must be controlled? Which geometric or probabilistic property makes the argument work? What roles are played by regularization, convexity, concentration, and stability? The blackboard format allowed me to develop proofs line by line and emphasize how apparently different results reuse common ideas.

I later designed a fourteen-lecture series titled *High-Dimensional Probability and Statistics for Data Science*. Each two-hour meeting had two parts: the first introduced a result or proof method from high-dimensional probability, and the second examined a paper in high-dimensional statistics that used it. Topics included concentration inequalities, random vectors, random matrices, chaining, covariance estimation, regression, and statistical learning. Attendance began at approximately twenty, with a core group of fewer than ten completing the full series; my doctoral advisor and two other professors also attended occasionally.

These courses taught me to organize advanced material around reusable proof strategies rather than isolated theorems. My preference is to explain the main mechanism of an argument in class while retaining enough detail for students to reconstruct the proof and recognize when the same technique can be used elsewhere.

Teaching Modelling of Dynamical Systems

From 2018 to 2020, I was a teaching assistant for *EL2820 Modelling of Dynamical Systems* at KTH. The course combined system identification, mathematical modelling, exercise sessions, computer exercises, laboratories, and examinations. I delivered nine two-hour exercise sessions during each offering and participated broadly in the course together with the other teaching assistants.

My responsibilities included teaching exercise sessions, working with students during laboratories, grading laboratory work, homework, quizzes, and examinations, and writing at least two examination problems each year. I also co-authored and revised the 2019 version of the course's computer-exercise booklet. The material guides students through nonparametric and parametric system identification, model selection and validation, experiment design, physical grey-box modelling, and nonlinear black-box identification.

The exercises were designed to connect preparation, computation, and the final laboratory. Students first completed mathematical derivations and then used MATLAB and the System Identification Toolbox to compare models, diagnose overfitting, analyse residuals, and study the consequences of sampling and experiment-design choices. I also helped replace one computer laboratory with homework assignments implemented as Jupyter notebooks, with the goal of distributing students' work more evenly throughout the course.

The course included students with varied preparation in linear algebra, probability, differential equations, and programming. To accommodate different preferred speeds, another teaching assistant and I offered complementary exercise sessions. His sessions gave a slower and more detailed treatment, while mine occurred later in the week, covered more material, and included additional extensions. Students could attend either session, attend both, or use the later session when they had missed the first.

I also remained available during breaks for students who did not want to ask questions in front of the whole class. These conversations were especially useful for students who were shy, lacked a prerequisite, or came from a different background. They often revealed the source of a difficulty more clearly than whole-class discussion.

To increase engagement, I connected standard exercises to more difficult versions drawn from earlier examinations. After completing the basic problem, I would show how the same idea appeared in a past exam and identify the additional conceptual step. This generated more useful interaction than my experiment with electronic clickers. The course material did not naturally support meaningful multiple-choice questions, and adapting it to the technology often made the questions superficial. Direct questions about the developing argument and carefully chosen exam extensions gave me better evidence of student understanding.

Teaching During COVID-19

The 2020 offering required the teaching team to redesign the course rapidly. I recorded all of my exercise sessions, including the complete mathematical development of the solutions, while continuing to offer in-person sessions for students who wished to attend. The lower in-person attendance allowed more direct interaction, while the recordings gave other students the ability to pause and revisit difficult derivations.

The three teaching assistants divided the remaining duties broadly equally. I participated in writing and grading quizzes and the take-home examination, supporting students through Canvas, email, Zoom, and discussion forums, and conducting the assessment and laboratory activities required by the course.

This experience showed me the complementary strengths of asynchronous and live teaching. Recordings are useful for worked examples, prerequisite reviews, and technical derivations that students may need to revisit. Live sessions are more effective for questions, comparison of approaches, and diagnosing misunderstandings. In future courses, I would use selected recordings to support preparation and review while reserving classroom time for reasoning and interaction.

Supervision and Mentoring

I have supervised bachelor's and master's thesis projects and collaborated with junior researchers on work that continued beyond the original degree project. At the beginning of a thesis, I help students turn a broad topic into a precise and feasible problem, identify the minimum background required, and separate the main objective from optional extensions. As the project develops, I gradually transfer responsibility to the student.

I co-supervised Archith Athrey's master's research at TU Delft and continued collaborating with him after the thesis. The project developed into a joint publication at the European Control Conference on learning-based linear-quadratic Gaussian control. My role included problem formulation, theoretical development, methodology, and analysis.

I also supervised an industrial master's thesis by Carl-Johan Larsson and Fredrik Håkansson in connection with Spotify. The project studied predictive caching of streaming media through vehicle-trajectory prediction and cellular-coverage information. I primarily mentored the machine-learning component, including recurrent-neural-network modelling, prediction, and evaluation using large-scale mobility data.

More recently, I have collaborated with Alexandre Alouadi on projects forming part of his doctoral research. The work has involved problem formulation, theoretical development, methodology, experimental design, and manuscript preparation.

An important part of research training is learning to distinguish a technical obstacle from a structural one. A technical obstacle may require a sharper estimate or a different computational method; a structural obstacle may indicate that the formulation itself should be changed. I try to help students develop this judgment rather than simply directing them toward the next calculation.

Principles and Future Teaching

My teaching is guided by four principles:

- **Structure before technique:** students should identify the objects, assumptions, and desired conclusion before choosing a theorem or algorithm.
- **Reusable ideas:** advanced courses should emphasize proof patterns such as concentration, conditioning, convexity, stability, approximation, and dynamic programming.
- **Theory connected to computation:** simulations and notebooks should investigate mathematical questions, test assumptions, or compare theory with finite-sample behaviour.
- **Progressive independence:** in both coursework and supervision, students should move from following arguments to proposing and evaluating their own approaches.

I am prepared to teach undergraduate and graduate courses in probability, mathematical statistics, stochastic processes, and statistical machine learning, as well as advanced courses in high-dimensional probability and statistics, optimal transport, and stochastic control.

I would also develop research seminars modeled on my KTH lecture series, with one part devoted to a mathematical tool and another to a research paper that uses it. This structure can help doctoral students move from coursework to independent reading and theoretical research.

Conclusion

My teaching has ranged from advanced blackboard lectures for small groups of researchers to exercises and laboratories for large engineering courses and individual thesis supervision. Across these settings, my objective is to help students understand mathematical structure, connect theory with modelling and computation, and develop the judgment required for independent problem-solving and research.