Machine Learning Course information





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"Statistics is merely a quantisation of common sense - Machine Learning is a sharpening of it!"

Who are we?

Tilman Plehn

Thea Arrestad

Malte Algren











Inar Timiryasov

Daniel Murnane

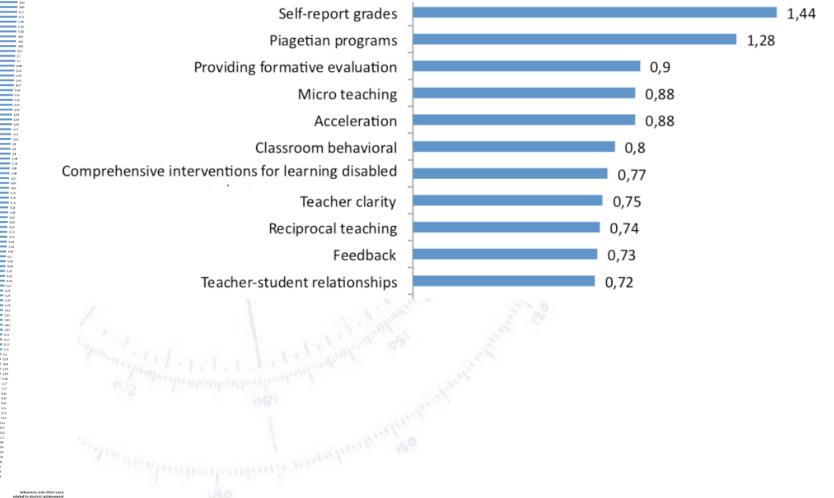
Troels Petersen

Our aim is for YOU to learn the most about ML and using it in physics research. If you have any wishes or feedback, don't hesitate to write us.

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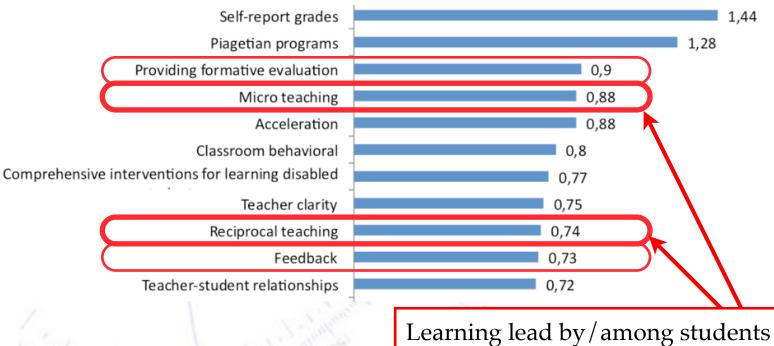
You can not teach a person anything! You can only help them discovering it in themselves... [Galileo Galilei]

There are studies of this, one result shown below:



related to student achievement Source Harto 2008 Visible Learning Distance www.idole-coming.org

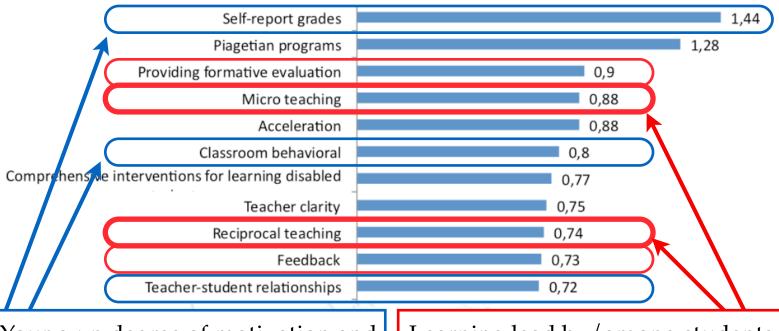
There are studies of this, one result shown below:



is among the **most effective ways**!

Influences and effect size
 related to student achieveme
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There are studies of this, one result shown below:

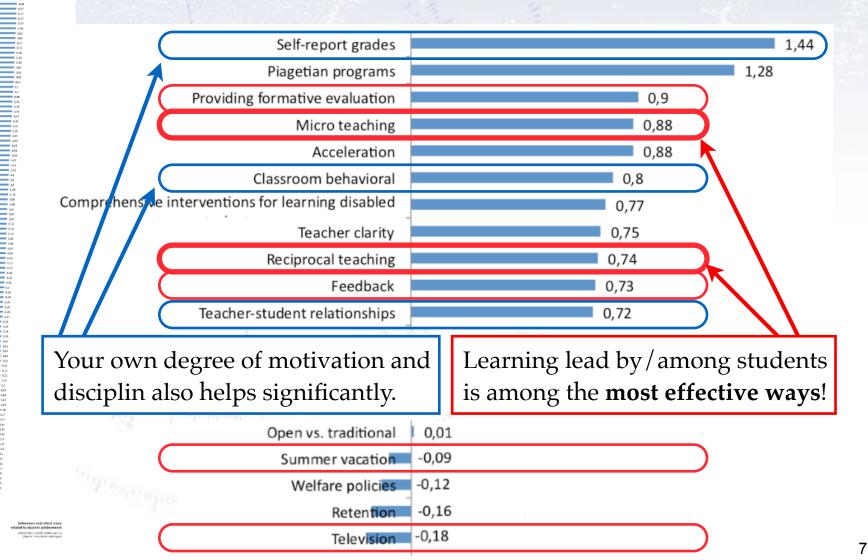


Your own degree of motivation and disciplin also helps significantly.

Learning lead by/among students is among the **most effective ways**!

Influences and effect sis related to studient achievem Source Hoto (2008 Visite Los Dispont www.eight-carrie

There are studies of this, one result shown below:



Locations for Ph.D. School

20

Exercises: (building K, top floor & Kc7) Yes, the balcony is for our use!

> Towards "Trianglen" Metro Station (200m) Also supermarket, pharmacy, etc.

Lectures: Auditorium A (up six stairs and in front) Information:

Address: Blegdamsvej 17 Nearest metro: Trianglen Troels mobile: +45 26 28 37 39

Locations for Ph.D. School

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Exercises: (building K, top floor & Kc7) Yes, the balcony is for our use!

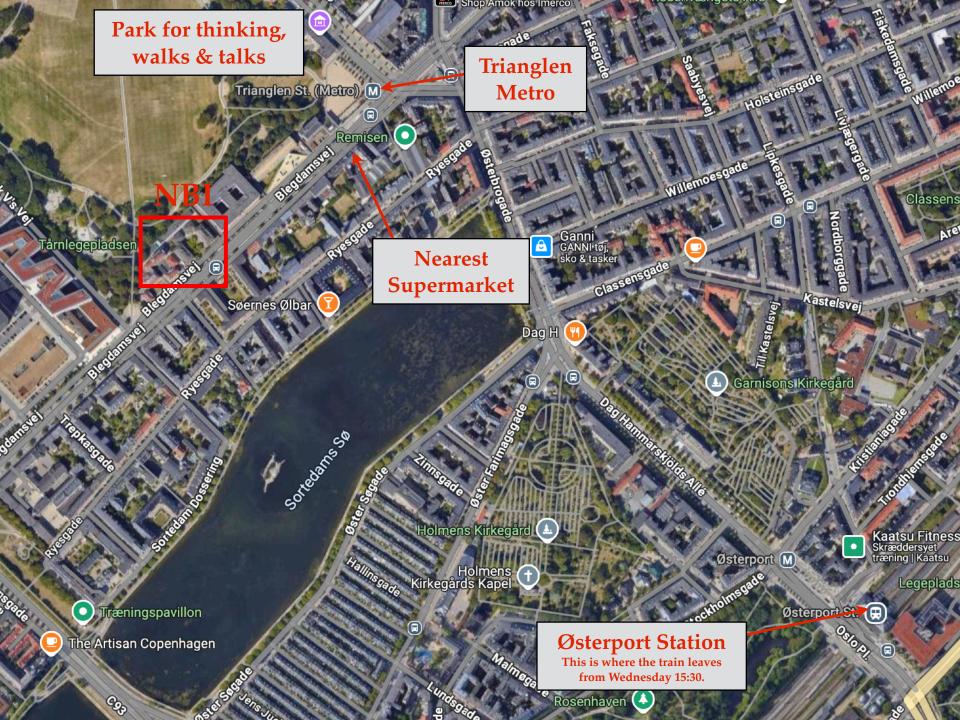
Don't use the Elevator

Path to K-building

Lectures: Auditorium A (up six stairs and in front) Towards "Trianglen" Metro Station (200m) Also supermarket, pharmacy, etc.

Information:

Address: Blegdamsvej 17 Nearest metro: Trianglen Troels mobile: +45 26 28 37 39





A normal day in school

Essentially all days (except Wednesday) look alike:

09:00	7 - Lecture 3: Bayesian Neural Networks	Tilman Plehn
	$\mathbf{T}_{\mathbf{A}} = \{\mathbf{A}, \mathbf{A}, \mathbf{A}, \mathbf{A}\}$	
	Lecture (Aud. A)	
10:00	Auditorium A, Niels Bohr Institute	09:00 - 10:15 _d
	Break	
	Auditorium A, Niels Bohr Institute	10:15 - 10:45
	8 - Lecture 4: Generative Networks, Likelihood vs. ML, Classifier test	Tilman Plehn
11:00		
	Lecture (Aud. A)	
	Lecture (11uu. 11)	
	Auditorium A, Niels Bohr Institute	10:45 - 12:00 _d
12:00	Lunch	
	Auditorium A, Niels Bohr Institute	12:00 - 13:00,
13:00	9 - Discussion of Lectures and intro to exercises Auditorium A, Niels Bohr Institute Discussion (Ke + Kc7)	
	Auditorium A, Niels Bohr Institute	13:00 - 13:30 _{,d}
	10 - Work on exercises	
	Exercise (Ke + Kc7)	
14:00	Exercise ($Re + RC7$)	
	Auditorium A, Niels Bohr Institute	13:30 - 14:30 _{,d}
	Break	
	Auditorium A, Niels Bohr Institute	14:30 - 15:00,
15:00	11 - Work on exercises	
	Exercise (Ke $+$ Kc7)	
16-00		
16:00		
	Auditorium A, Niels Bohr Institute	15:00 - 16:30

A special day in school

Wednesday will be a bit different.

09:00	12 - Lecture 5: Generative Adversarial Networks and Introduction to Diffusion and Flow	Tilman Plehi
	Lecture (Aud. A)	
10:00	Auditorium A, Niels Bohr Institute	09:00 - 10:1
	Break	
	Auditorium A, Niels Bohr Institute	10:15 - 10:4
	13 - Lecture 6: Diffusion and Flow techniques	Malte Algre
11:00	Lecture (Aud. A)	
	Auditorium A, Niels Bohr Institute	10:45 - 12:
12:00	Lunch break	
	Auditorium A, Niels Bohr Institute	12:00 - 13
13:00	14 - Discussion of Lectures and intro to exercises Auditorium A. Niels Rath Institute Discussion (Ke + Kc7)	
		13:00 - 13:
	15 - Work on exercises	
14:00	Exercise (Ke + Kc7)	
14.00	````'	
	Auditorium A, Niels Bahr Institute Packing up, walking to Østerport train station, and preparing for boarding train.	13:30 - 14:
	r usong up, maning to sourciport sum anaton, with preparing to bounding sources	
15:00	Excursion: Train, Castle, Drinks & Dinner	
		14:30 - 15:
	16 - Train ride to Helsinger, visit to Kronborg Castle, drinks on the ramparts, and dinner at Værftets Madmarket.	14.00 - 10.
16:00		
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WebBlogs as literature

In ML, blogs/articles/tutorials are a very common (and great) source of literature on ML. For this reason, we've made a list of links that we find good:

Applied Machine Learning 2025 - Useful ML links

The field of Machine Learning (ML) is developing at a very fast pace and by an expanding number of practitioners. For this reason, text books on ML are typically few and slightly d describe the general concepts very well. Research papers have partially filled the gap, as these are more versatile and frequently updated. However, they typically only deal with a ver generel ML "phase space".

But whereas "classic" literature (i.e. books and papers) only covers partially, blogs and github repositories seem to fill out the rest, and typically in a much more accessible fashion wi example code. For this reason, we have tried to gather some of the more useful links to such blogs and repositories below. It is simply our (slightly random) selection of webpages the found illustrative and useful. So use these at will, and also build your own list of reference sites.

Books:

- · Applied Machine Learning by David Forsyth. Great book, at times even mildly entertaining, from one of the masters of ML vision.
- <u>Elements of Statistical Learning II</u> by Trevor Hastie et al. Second eddition of standard book on fundamentals.
- Machine Learning (from PDG) by Kyle Cranmer et al. (2021). A concise (60 page) overview
- Deep Learning by Ian Goodfellow et al. (2016). A short and good general introduction to ML can be found in Chapter 5 of Part 1.
- Pattern Recognition and Machine Learning by Christopher M. Bishop (2006).
- "Interpretable Machine Learning" by Christoph Molnar (2020). A Guide for Making Black Box Models Explainable.
- "Convolutional Neural Networks for Visual Recognition" by Andrej Karpathy (2017?). Used for teaching CNN in Stanford's cn231 class.
- "Deep Learning with Python" by author of Keras, Francois Chollet, now at Google AI (2017). Especially chapter 4 is a good overview of the fundamentals of Machine Learning.
- Book on neural networks and deep learning. Online book only!
- Pattern Recognition and Machine Learning (2006) by Christopher M. Bishop is a classic (if older) standard reference.

Papers:

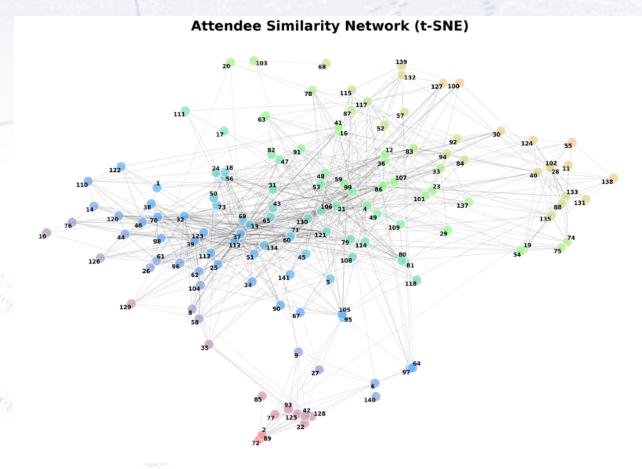
- XGBoost paper (2016). Highly readable paper showing the innovations of the XGBoost algorithm.
- LightGBM paper (2017). Explaining the great speedup and showing examples of execution times.
- More general paper (100 pages) on Geometric Deep Learning: Grids, Groups, Graphs, Geodesics, and Gauges (2021).
- <u>ROCKET: Time series classification using random convolutional kernels</u>
- ٠

Blogs/Links/Tutorials - supervised learning:

- Introduction to tree based learning. Very good introduction to the basics of tree based learning.
- Introduction to neural net based learning. Very good introduction to the basics of Neural Net (NN) based learning.
- · SciKit Learn tutorial. Gives a quick introduction to ML in general and has code examples for SciKit Learn.
- XGBoost vs. LightGBM. Discussion of differences, with code examples.
- XGBoost, LightGBM, and CatBoost. Discussion of differences and hyperparameters.
- Introduction to NGBoost, which is a tree based algorithm, which makes a probabilistic predictions (i.e. uncertainties).

Who are the others? Like me?

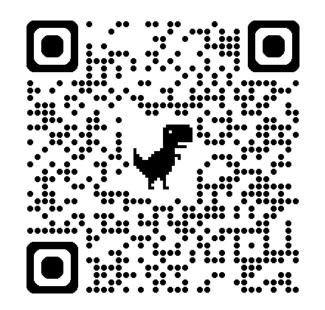
In order to let everyone get an idea of who is who at this school, we wanted to try to find out, who were alike/dislike. Using your registration information, one could imagine getting the following pattern came out:



Who are the others? Like me?

Using an LLM, Daniel put together a short Physics-ML Bio of everyone, which can be found using the conference numbers here: <u>https://hamlet-conf.github.io/nbi-school-25/</u>

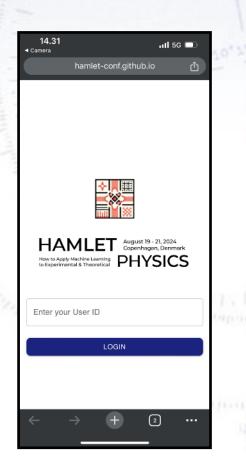
Try to look up yourself...



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Try to look up yourself...



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The HAMLET MeetUp App

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Op	ening Line	
ne	et's explore how our graph r etworks expertise can revolu article physics research."	
D	iscussion Points	^
1.	Both of us have an interest applying graph neural netwo (GNNs) in our research. Ho we possibly leverage our co expertise to explore novel p in particle physics or beyon	orks w could ombined problems
2.	Considering that we are bolt the Niels Bohr Institute and similar ML methods, what a specific ways we can collab share insights on projects re to anomaly detection and do optimization?	use re some orate or elated
3.	With one of us working on t Next-to-Minimal Composite Model and the other on experimental particle physic do we see the crossover be theoret ieal models and	Higgs cs, how

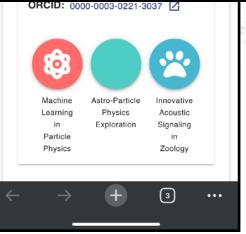
The HAMLET MeetUp App

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Play around with this tool, and don't hesitate to give us feedback.

Happy App'ing...

	ID	Name	Similarity	
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2	99	Johann Ioannou- Nikolaides	0.77	1.1
	106	Arnau Morancho Tarda	0.77	ordently
	53	Martin Langgård Ravn	0.76	
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in particle physics or beyond?

- Considering that we are both from the Niels Bohr Institute and use similar ML methods, what are some specific ways we can collaborate or share insights on projects related to anomaly detection and data optimization?
- With one of us working on the Next-to-Minimal Composite Higgs Model and the other on experimental particle physics, how do we see the crossover between theoreties! models and _____

Code of Conduct

This Ph.D. school is a community event intended for presentations, networking and collaboration. We value a civil and respectful environment which encourages the free expression and exchange of scientific ideas.

All attendees are expected to adhere to the CERN Code of Conduct.

Should a lapse of professional decorum occur, attendees are encouraged to bring issues, in a confidential setting, to the advisors appointed by the conference organisers.

The advisors will suggest ways of redressing the matter and counsel the parties involved. The conference organisers may, after due consideration, take action as they deem appropriate, including, in severe cases, expulsion from the school.

If you believe someone is violating the code of conduct, we ask that you report it by emailing Daniel Murnane (daniel.murnane@nbi.ku.dk) and/or Troels C. Petersen (<u>petersen@nbi.dk</u>).

Essential Links

ML links:

https://www.nbi.dk/~petersen/Teaching/ML2025/MLlinks.html

GitHub for school exercises:

https://github.com/troelspetersen/PhDschool2025_AppML

Link to "Kaggle Challenge" setup/rules: <u>https://www.nbi.dk/~petersen/PhDschool2025/PhDschool2025_InitialProject.html</u>

Google link for submitting "Kaggle Challenge" solutions: <u>https://docs.google.com/forms/d/1_IHeU9aBWtbQQza1c9thweWhc47qcZZBWxU-fKd0V9s/edit</u> Deadline is Thursday at noon - we will then start to evaluate the solutions.

The "School Proximity" MeetUp App:

https://hamlet-conf.github.io/nbi-school-25/

Computers & Internet

The Niels Bohr Institute have "eduroam" wifi network (thus the usual channel).

For the exercises (K-building), we have setup an addition WIFI source:

WiFi: NC-SummerUniversity Password:

Sommer2025!

ML is a big field - so don't worry if you don't understand everything!

"Magic Trail" in Nepal... or a loss landscape...

BETWEEN MODELS AND REALITY: PH.D. SCHOOL ON MACHINE LEARNING IN PHYSICS

Anja Butter (LPNHE) Tilman Plehn (Heidelberg) Juergen Hesser (Heidelberg) Bogdan Malaescu (LPNHE) Bertrand Laforge (LPNHE) Stefano Forte (Milan) Stefano Carrazza (Milan) Vincenzo Piuri (Mila-Xavier Fresquet (Sorbo Tobias Golling (Geneva Svyatoslav Voloshynovs

Speakers:

Tilman Plehn (Heidelberg) Daniel Murnane (NBI) Thea Aarrestad (ETH - Zur Malte Algren (Geneva) Troels C. Petersen (NBI)

All lectures will be held in the historic additoring

A in central Copenhagen.

Local organising committee: Troels C. Petersen (NBI)

> Daniel Murnane (NBI) Inar Timiryasov (NBI) lean-Loup Tastet (DIKU) Rasmus Ørsøe (TUM)

Johann Ioannou-Nikolaides (NBI)



NIELS BOHR INSTITUTE, COPENHAGEN, 2ND - 6TH OF JUNE 2025 https://indico.nbi.ku.dk/event/2153/

