Towards a virtual campus in engineering mathematics

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ECMI 2021

Joint work with
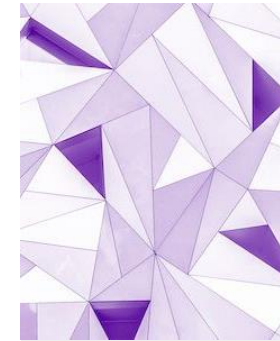
Technology supported mathematics education research group

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... any many other teachers, teaching assistants, collaborators - and students!

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Vectors and matrices

Engineering mathematics at Tampere University

Four mandatory courses, 5 credits each:

• Fundamentals of engineering mathematics

• Vectors and matrices

• Differential and integral calculus

• Introduction to probability and statistical inference
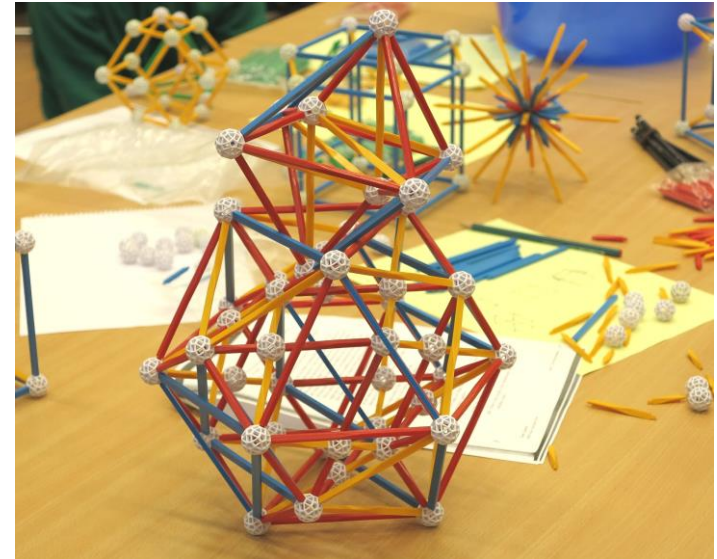
"Flipped" implementations for about 300 students yearly, another 300-400 students study the courses more traditionally.

Vectors and matrices

- Students from three Tampere University campuses & FiTech Network University
  - FiTech is collaborative project of seven Finnish universities of technology that offer university courses free of charge to degree students and adult learners (graduates and company representatives)

- Teaching based on flipped learning ideology: online learning platform, written material, lots of small problems to work on, videos, discussion forum, problem sessions (online), small group meetings with teacher (online)

- Weight of continuous assessment 70-85%, final exam 15-30%
  - Students collect points from online problems, written solutions to homework, self- and peer-assessments, learning portfolio / group work, and final exam

Vectors and matrices: self-study phase

Students study each week a new topic with provided online material:

- Course notes with theory, examples and problems
- STACK problem set (automatically assessed, randomised problems)
- Short videos

Pisteet **0 / 1**   Palautukseni **0 / 5** ▾   Määräaika tiistai 1.6.2021 22:00

Tehtävä 1

Kysymys 1

1 piste Valitse paikkansa pitävät väittämät. Oletetaan, että $A, B \in \mathbb{R}^{m \times n}$ ja että $\mathbf{b} \in \mathbb{R}^m \setminus \{\mathbf{0}\}$.

☐ Jos $\mathbf{s}$ on matriisiyhtälön $A\mathbf{x} = \mathbf{0}$ ratkaisu, niin myös $2\mathbf{s}$ on ratkaisu.

☐ Jos $\mathbf{s}$ on matriisiyhtälön $A\mathbf{x} = \mathbf{b}$ ratkaisu, niin myös $2\mathbf{s}$ on ratkaisu.

☐ Jos A on matriisi ja $A\mathbf{x} = O$ kaikilla vektoreilla $\mathbf{x}$, niin $A = O$ on nollamatriisi.

☐ Jos $AB = O$, niin $A = O$ tai $B = O$.

☐ Jos A ja B ovat neliömatriiseja, niin $(A + B)^2 = A^2 + 2AB + B^2$.

Lähetä

Pohdi 3.1.1

Ruska ja Tuisku ovat lähdössä ruokaostoksille ja vertailevat hintoja kahdessa lähikaupassaan. Alla olevassa taulukossa on heidän kauppalistansa sekä ruokatavaroiden hinnat eri kaupoissa:

	maitoja	sämpylöitä	jogurtteja
Ruska	6	4	4
Tuisku	6	2	3

	Y-kauppa	T-valinta
maito	1,40 e	1,30 e
sämpylä	1,10 e	1,15 e
jogurtti	0,50 e	0,60 e

1. Kuinka monta jogurttia Tuisku aikoo ostaa?
2. Mitä kaikkea Ruska on ostamassa ja kuinka paljon?
3. Mitkä ovat tuotteiden hinnat T-valinnassa?

Kuten Ruskan ja Tuiskun tapauksesta nähdään toisinaan asiat on kätevä kirjoittaa muistiin taulukkoon. Matematiikassa lukutaulukoita kutsutaan matriiseiksi. Esimerkiksi Ruskan ja Tuiskun kauppalistan voi kirjoittaa matriisina

$$A = \begin{bmatrix} 6 & 4 & 4 \\ 6 & 2 & 3 \end{bmatrix}$$

ja ruokatavaroiden hinnat matriisiksi

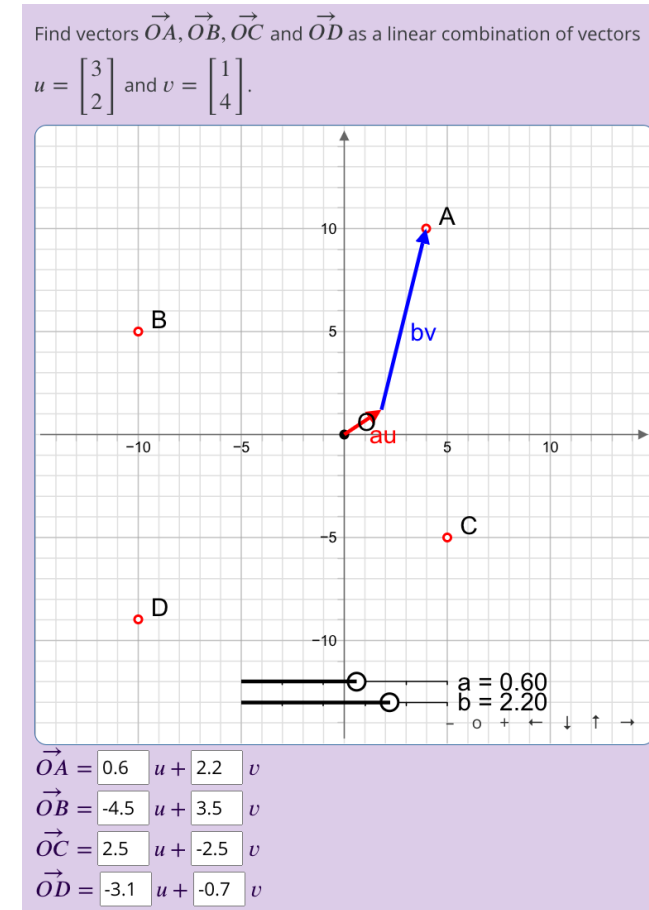$$B = \begin{bmatrix} 1,40 & 1,30 \\ 1,10 & 1,15 \\ 0,50 & 0,60 \end{bmatrix}.$$

About STACK

- STACK (System for Teaching and Assessment using a Computer algebra Kernel) is an online assessment system for mathematics and STEM, designed to enable students to answer questions with a mathematical expression, such as a polynomial. It is available for Moodle.

- STACK uses the Computer Algebra System Maxima to evaluate expressions which enables for example randomised questions and specific feedback
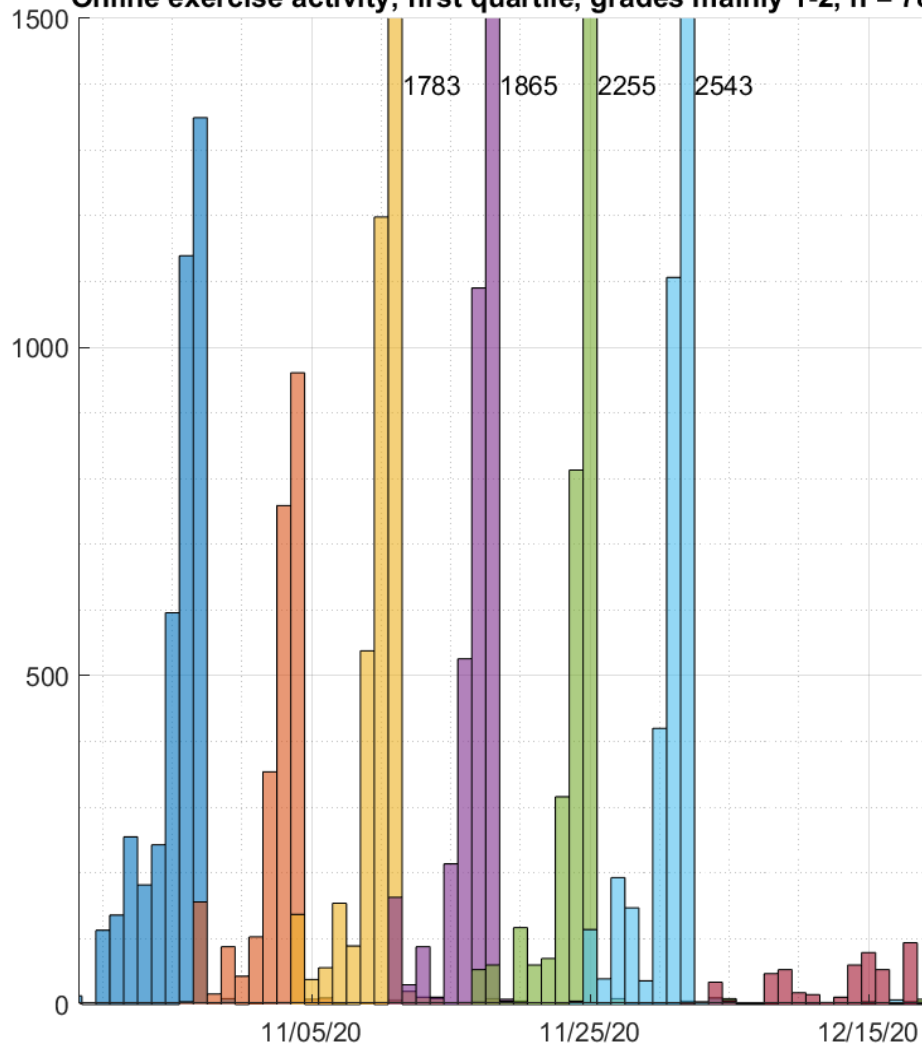
- https://stack-assessment.org/
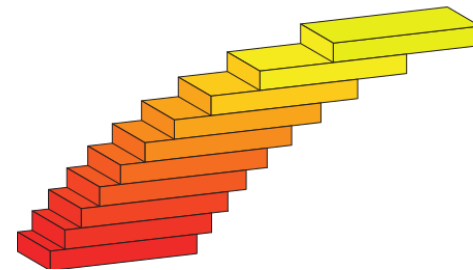
Vectors and matrices: self-study phase

- Each learning week, the students had about 15 STACK problems to solve

- The idea of STACK problems was not only to test the students' knowledge but also to support their learning process and deepen their understanding

Find vectors $\vec{OA}, \vec{OB}, \vec{OC}$ and $\vec{OD}$ as a linear combination of vectors $u = \begin{bmatrix} 3 \\ 2 \end{bmatrix}$ and $v = \begin{bmatrix} 1 \\ 4 \end{bmatrix}$.

a = 0.60
b = 2.20

$\vec{OA} =$ [0.6] $u +$ [2.2] v

$\vec{OB} =$ [-4.5] $u +$ [3.5] v

$\vec{OC} =$ [2.5] $u +$ [-2.5] v

$\vec{OD} =$ [-3.1] $u +$ [-0.7] v

Vectors and matrices: Online exercise activity

Online exercise activity, first quartile, grades mainly 1-2, n = 78

1783   1865   2255   2543

Online exercise activity, top quartile, grade 5, n = 78

Week 1
Week 2
Week 3
Week 4
Week 5
Week 6
Week 7, optional
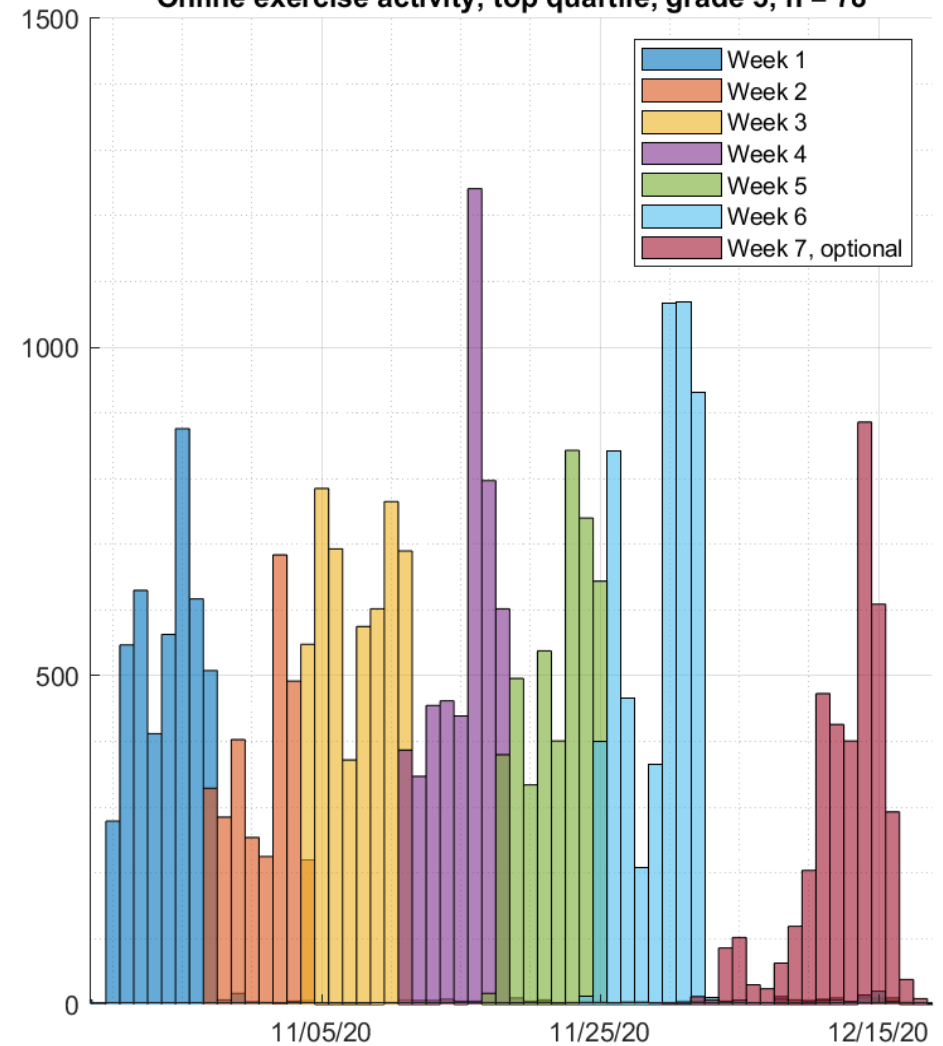
Vectors and matrices: group study phase

Problem sessions

- Several small groups and teaching assistant(s)
- Students discuss solutions to pre-problems and work together on homework problems

Prime time meetings

- One small group (5-8 students) and teacher
- Discussion on the week's topics
- Group solves a few harder problems together

Vectors and matrices: final exam

- The final exam was open book remote Moodle exam
- In the exam there were STACK questions and questions which required PDF attachment
- The exam was open for one week but the time limit was 3 hours
- Before of Covid-19 we had closed book exams in computer labs where we also used STACK questions and students had MATLAB available

Vectors and matrices: final exam

Correlation of exam points with various activities
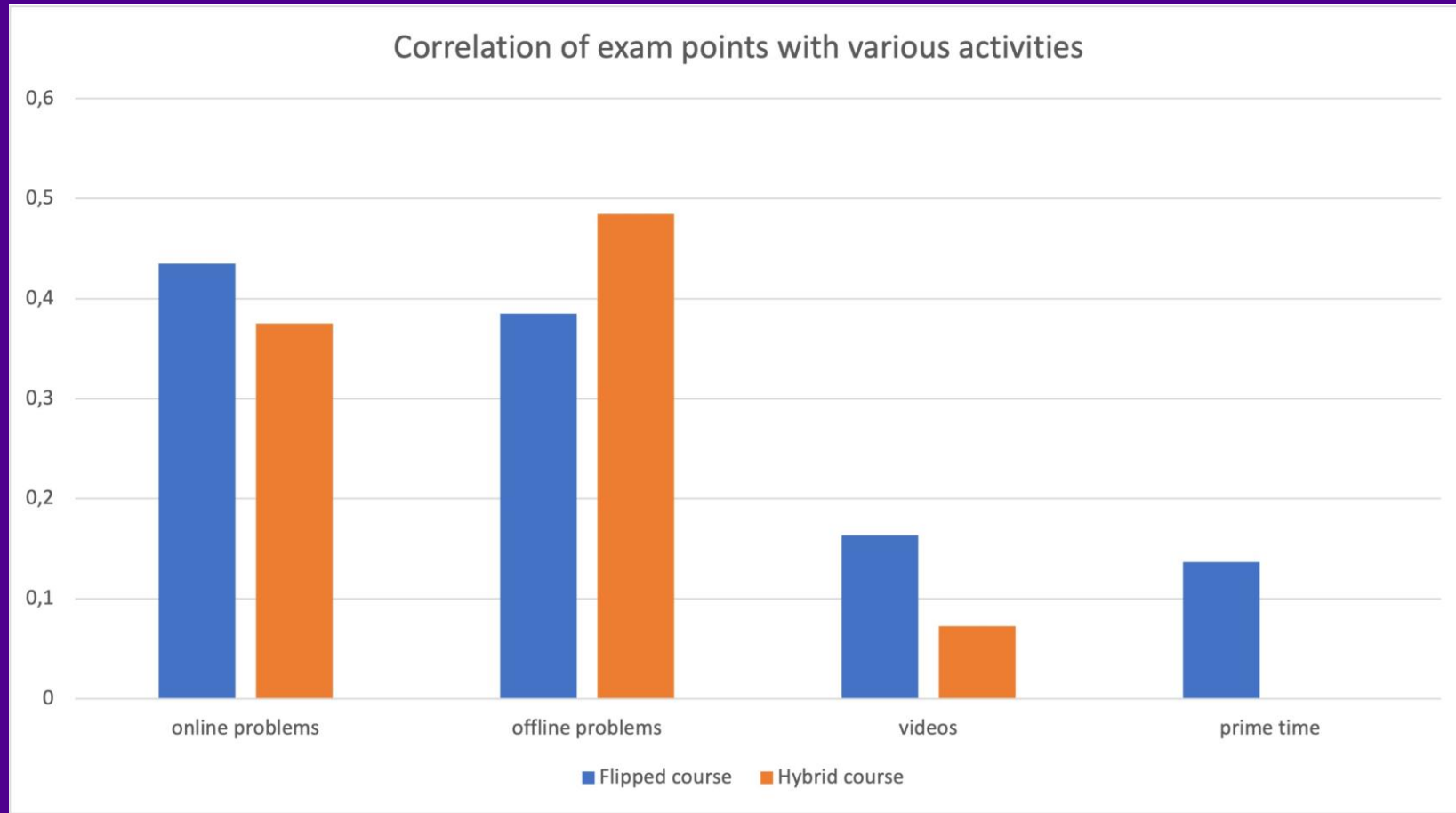
Teaching and learning mathematical modelling on the Web

https://webpages.tuni.fi/matemaattinenmallinnus/finnish-network-mathematical-modelling/

Finnish Network on Mathematical Modelling

- **The purpose of the network is to develop Web-based learning and teaching methods in mathematical modelling.**

- **Cross-national, participating universities**
  - Tampere University,
  - Aalto University,
  - University of Eastern Finland,
  - University of Jyväskylä,
  - Lappeenranta University of Technology and
  - University of Oulu

- **Basic course on mathematical modelling (5 cr) is the most popular course**
  - Fully online since 2002. From 2002 to 2020, in total, 1570 students have completed the courses
  - Contains 8 moduls and project work. Each two-week modul is based on videos by experts, practise problems and group work.

- **Two advenced level courses**
  - Advanced mathematical modelling: Continuous models (5 cr)
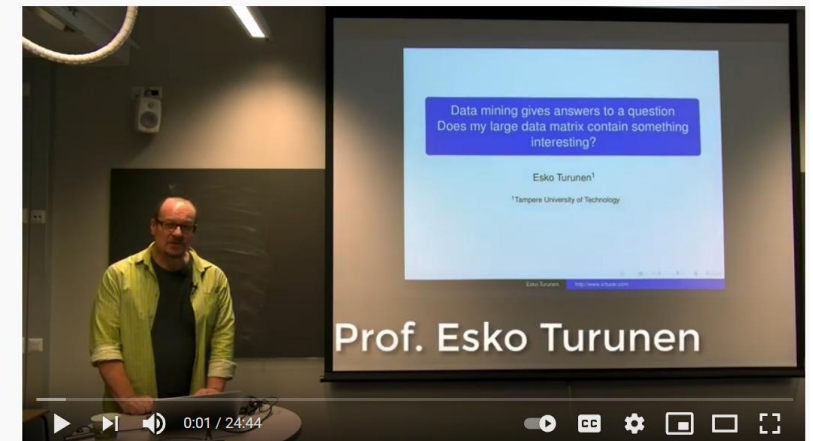 - Advanced mathematical modelling: Discrete modelling (5 cr)

  https://www.youtube.com/channel/UC9gZ4VrQQIaYd-irZATtPRQ/videos
  https://webpages.tuni.fi/matemaattinenmallinnus/coursework-examples/

Thanks!

Online exercise activity, first quartile, grades mainly 1-2, n = 78

Online exercise activity, top quartile, grade 5, n = 78