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Flipped learning and basic psychological need satisfaction in engineering mathematics

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Flipped learning research in TUNI

Research on flipped learning in Tampere University focuses currently on technical areas and is conducted in collaboration with two research teams.

- **First research team** consists of two research groups: Technology-Enhanced Mathematics Teaching Research Group, TTMOT and Professional Growth and Learning Research Group, PGL.
  - **Study 1** investigates engineering higher education **students'** trait and state level characteristics (e.g., goal orientations) and study success in traditional and flipped teaching engineering mathematics courses.
    - 2019-2020: Higher education students on four subsequent engineering mathematics courses. (**completed**)
    - 2020-2021: Higher education students on four subsequent engineering mathematics courses. (**on-going**)
- **Second research team** consists of researchers from University of Eastern Finland and University of Turku.
  - **Study 2** focuses on engineering higher education **students**' motivation, study and self-regulation skills, and **teachers'** teaching experiences in flipped and non-flipped engineering courses.
    - 2019-2020: Physics, materials science and computer science students and teachers. (**completed**)
    - 2020-2021: Physics, chemistry, architecture, automation and engineering mathematics students and teachers. (**on-going**)

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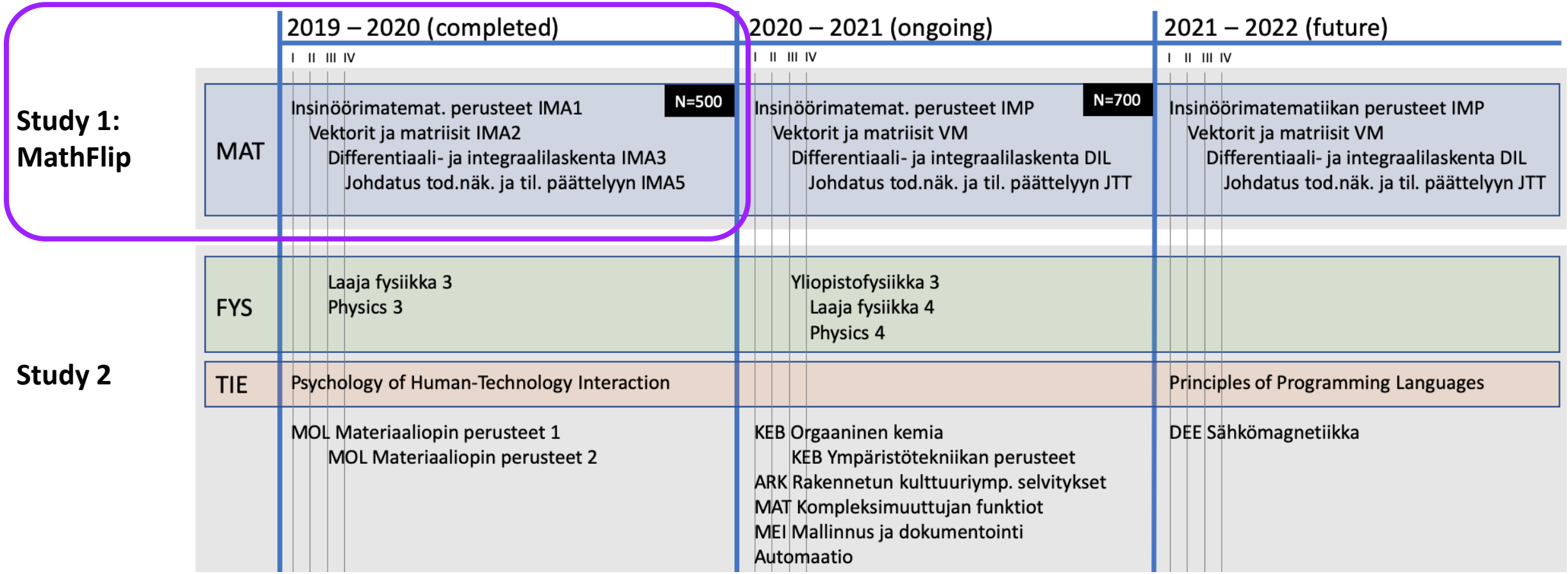
Flipped learning research in TUNI



MathFlip

Eight month longitudinal study (08/2019 – 04/2020) focused on first year university students' (*N* = 405) characteristics, learning experiences and outcomes during four engineering mathematics courses that were implemented with traditional (*n* = 216; lectures, exercises) and flipped (*n* = 189; no lectures, but self-study and small group meetings) teaching.

Goal of the research was to learn **if the pedagogical implementation (Trad/Flip) is related to the development of students' 1) mathematical skills, 2) approaches to learning, 3) goal orientations, 4) self-efficacy, 5) basic psychological need satisfaction and 6) emotions**.

Quasi-experimental within and between subjects design contained repeated self-assessments (survey, interview, diary) and objective (math exam score, electrodermal activity) measurements.

The study was conducted in collaboration with two research groups:

- **Technology-Enhanced Mathematics Teaching (TTMOT)** https://research.tuni.fi/ttmot/tutkimusryhma
  - Terhi Kaarakka, Simo Ali-Löytty, Jani Hirvonen, Riikka Kangaslampi, Johanna Rämö, Elina Viro
- **Professional Growth and Learning (PGL)** https://research.tuni.fi/pglresearch
  - Petri Nokelainen, Susanna Hartikainen, Essi Saario, Jenni Piirto, Ilmari Puhakka, Eija Lehtonen, Tiia Lehtinen

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MathFlip – Flipped learning implementation

The flipped model involved a weekly two-hour primetime session (cf. Koskinen et al., 2018) and a two-hour problem session.

- Students were divided into groups of approximately eight students, and they worked with their groups in both the primetime and the problem sessions. There were no lectures.

Students started studying a new topic by reading the Finnish course material or English textbook and watching short video lectures.

- They worked on homework tasks, including both pen and paper tasks and digital tasks giving automatic feedback. Some of the tasks were the same as those used in the traditional implementation. Some were different, since the flipped model paid special attention to developing not only procedural skills, but also students' conceptual understanding (Hiebert & Lefevre, 1986). Students completed half of the pen and paper tasks before discussing them in problem sessions similar to those used in the traditional model; for the other half, they could use the problem sessions to ask for help.

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MathFlip – Flipped learning implementation

After the problem sessions, the tasks were submitted and then self- and peer-assessed.

- Students also self-assessed their competencies every week using the course's learning objectives.

Finally, the students attended primetime sessions that summarized the week's topics.

- Each group had a 40-minute conversation with the teacher concerning the learning outcomes, topics they found unclear, and study skills. While the teacher was discussing with one group of students, the others worked on tasks that recapped or expanded the week's topics.

Students' grades were based on the tasks and other activities completed during the course (70%) and a final exam (30%).

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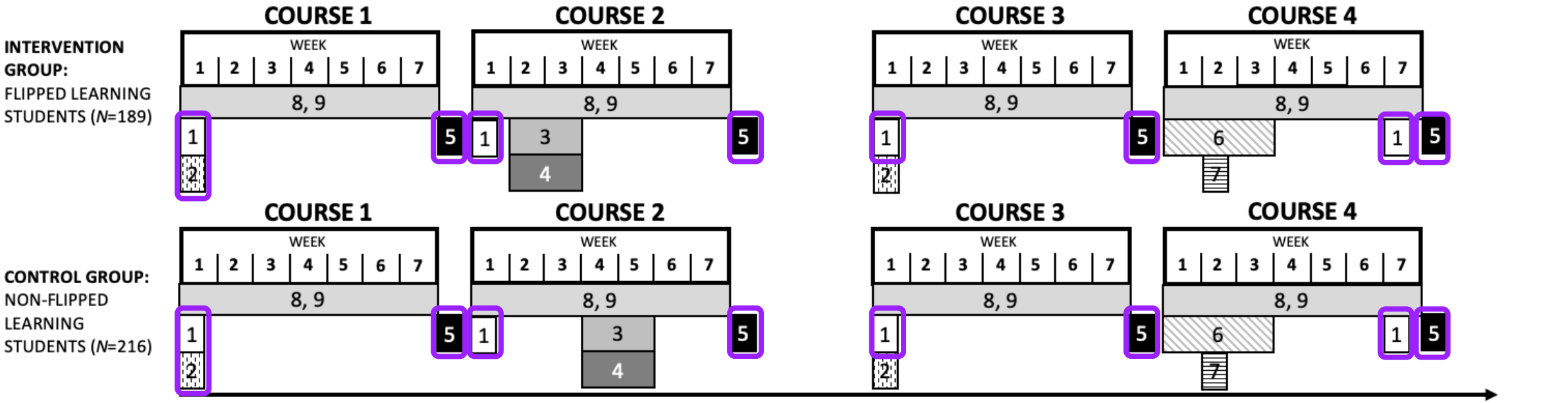
MathFlip - Design



1 SURVEY (1 AL Approaches to learning, 2 EMT Emotions, 3 GO Goal orientations, 4 SE Self-efficacy, 5 BPNS Basic psychological needs) N=405

2 MATHEMATICAL ABILITY TEST (9 MATP) N=405

3 PHYSIOLOGICAL MEASUREMENT (6.1 EMS Arousal: Moodmetric smart ring) N=60

4 EXPERIENCE SAMPLING MEASUREMENT (6.2 EMS Emotions: LearningTracker) N=60

5 COURSE EXAMINATION (10 MATF Final grade) N=405

6 INTERVIEW (14 EXP, Experiences related to math learning) N=16

7 SURVEY (age, gender, discipline, 6 items measuring attitude and experiences of math studies) N=405

8 MATHEMATICAL ABILITY (11 MATA Activity level of completing exercises, 12 MATE Online/offline exercise scores) N=405

9 TIME AND RESOURCE MANAGEMENT (13.1 TRM B/C Video watching times, 13.2 TRM C Weekly self-assessment) N=405

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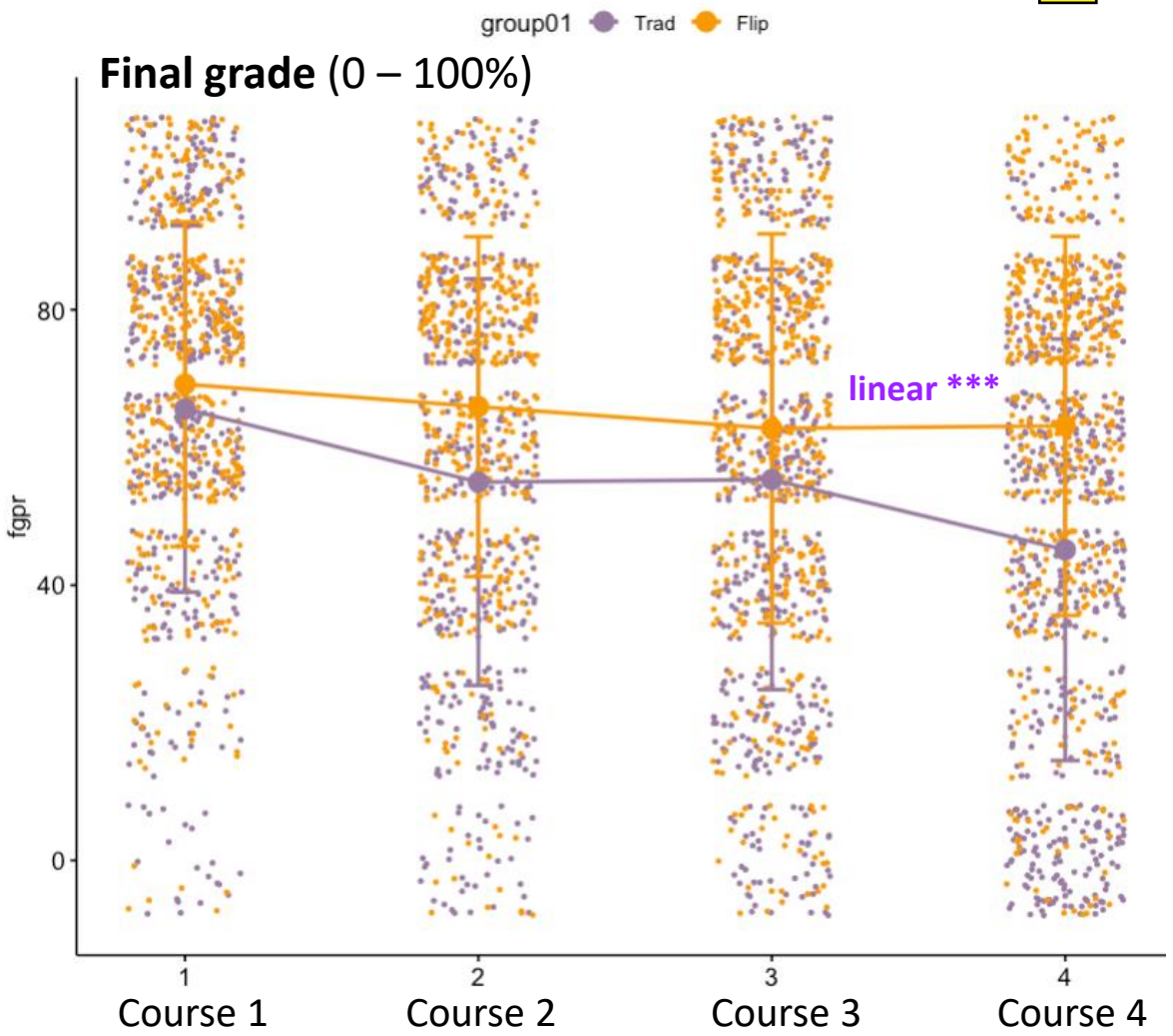
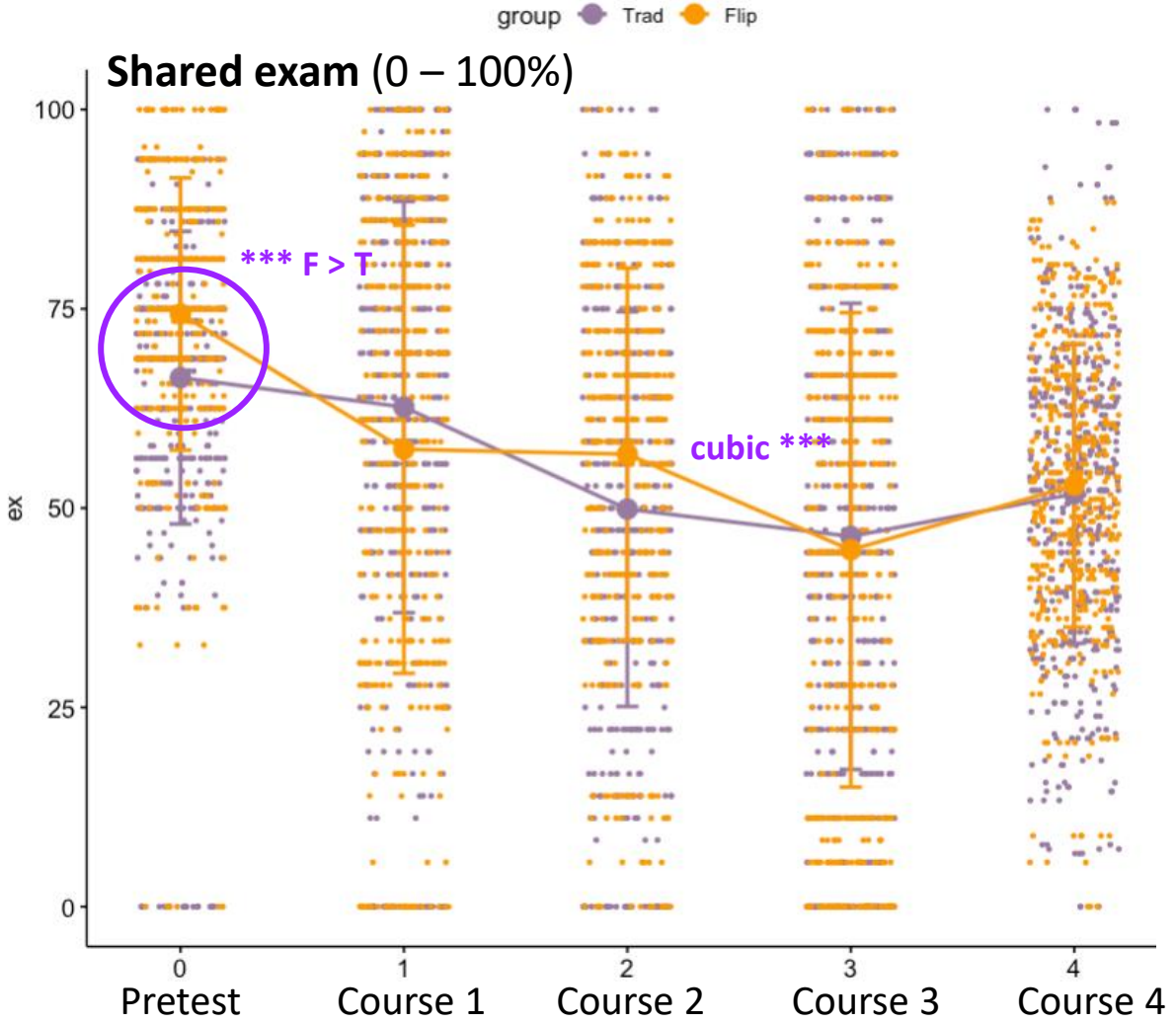
How pedagogical implementation (Trad/Flip) is related to the development of **students' mathematical skills** (final grade, shared exam score)?

Trad (*n* = 216, 53.3%)

Flip (*n* = 189, 46.7%)





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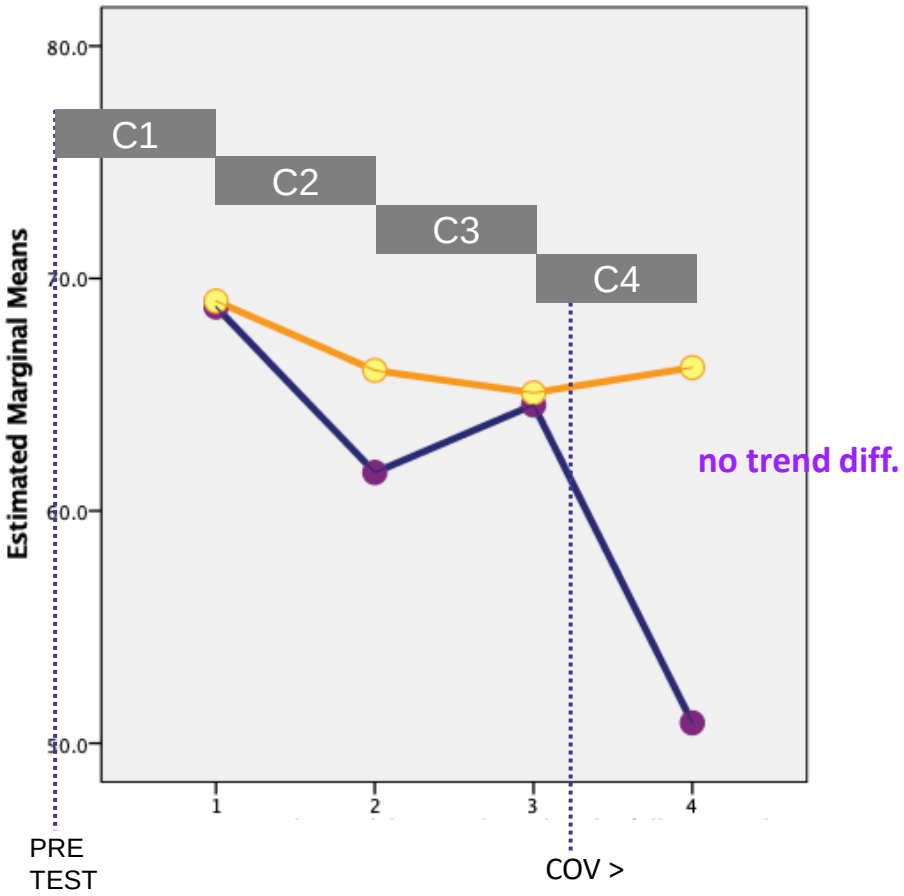
How pedagogical implementation (Trad/Flip) is related to the development of female and male students' mathematical skills (final grade, shared exam score) **after controlling for the pretest score**?

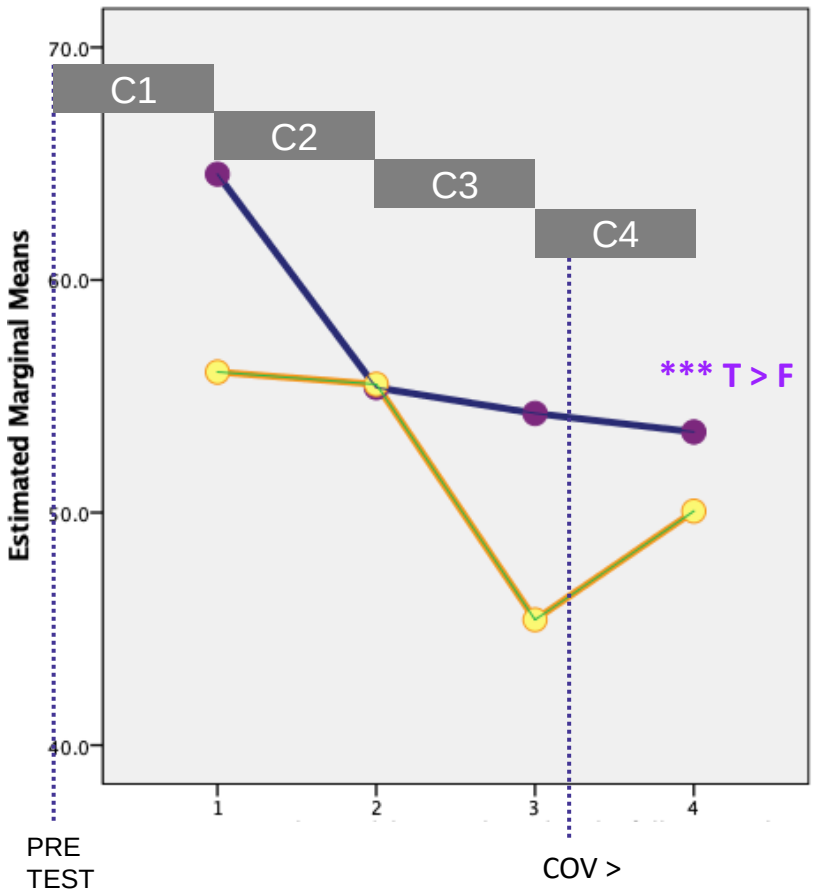
Final grade (0 – 100%)



Trad (*n* = 216, 53.3%)

Flip (*n* = 189, 46.7%)

Shared exam score (0 – 100%)



Final grades over time controlled for the pretest score

Shared exam scores over time controlled for the pretest score

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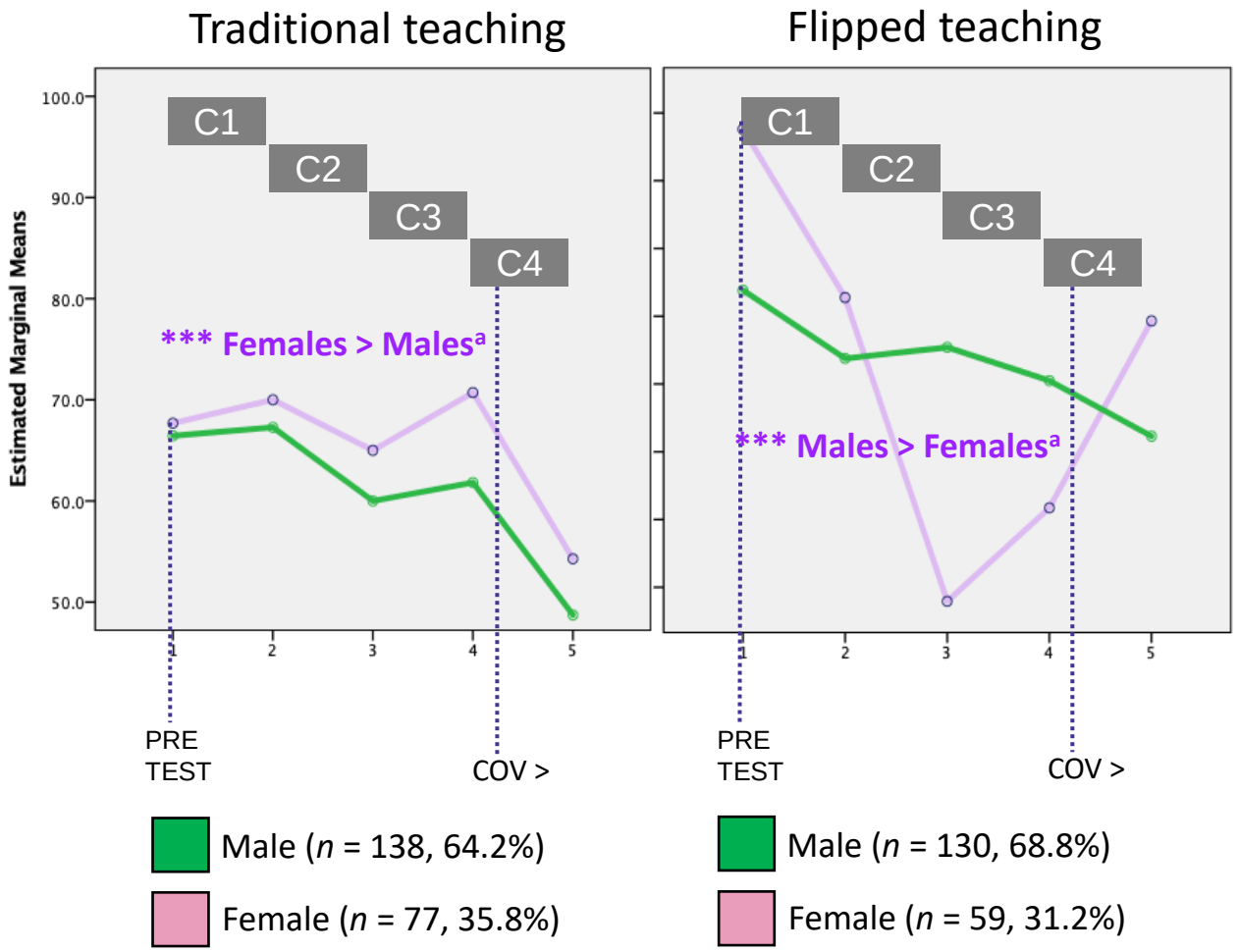
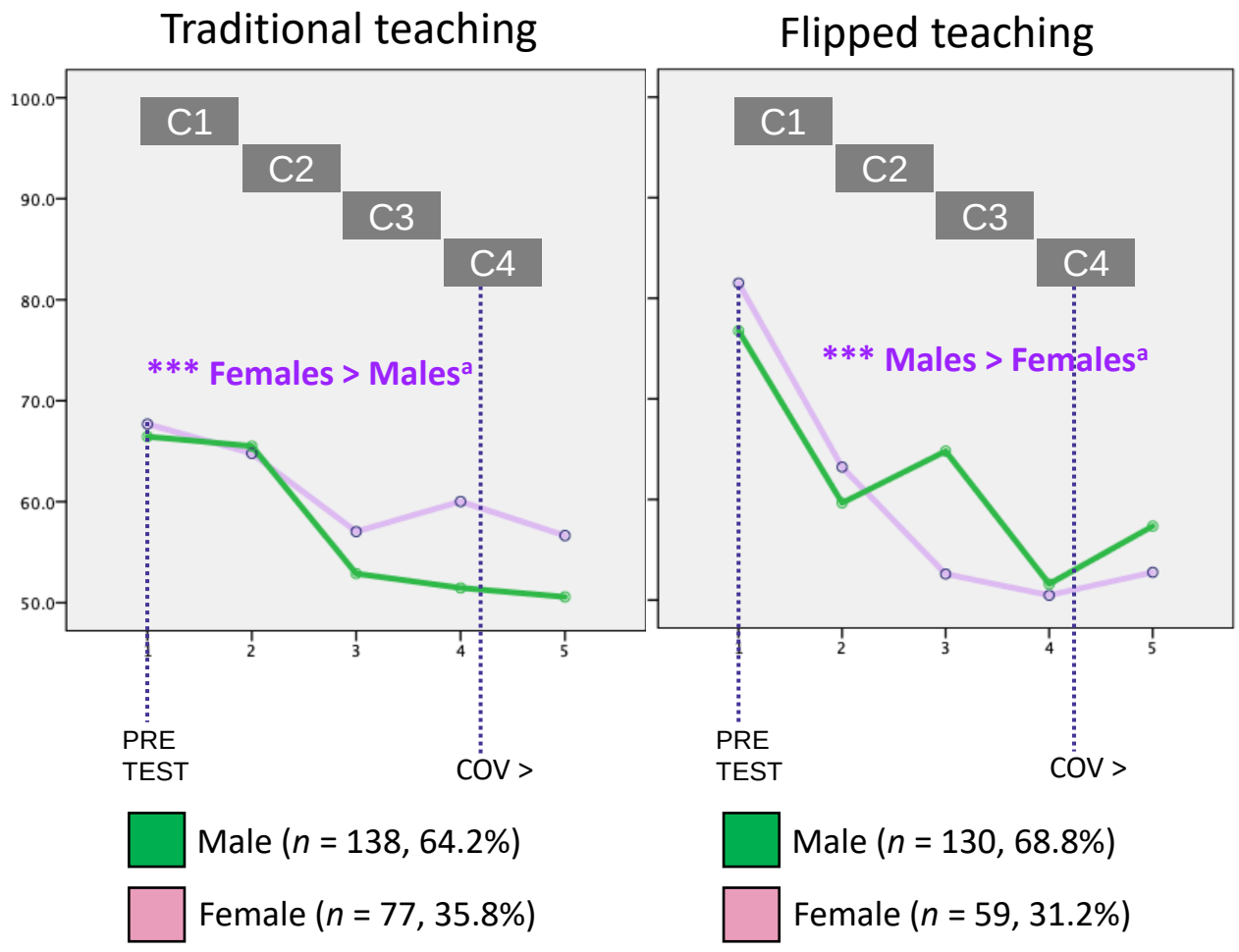
How pedagogical implementation (Trad/Flip) is related to the development of **female** and **male** students' mathematical skills (final grade, shared exam score)?

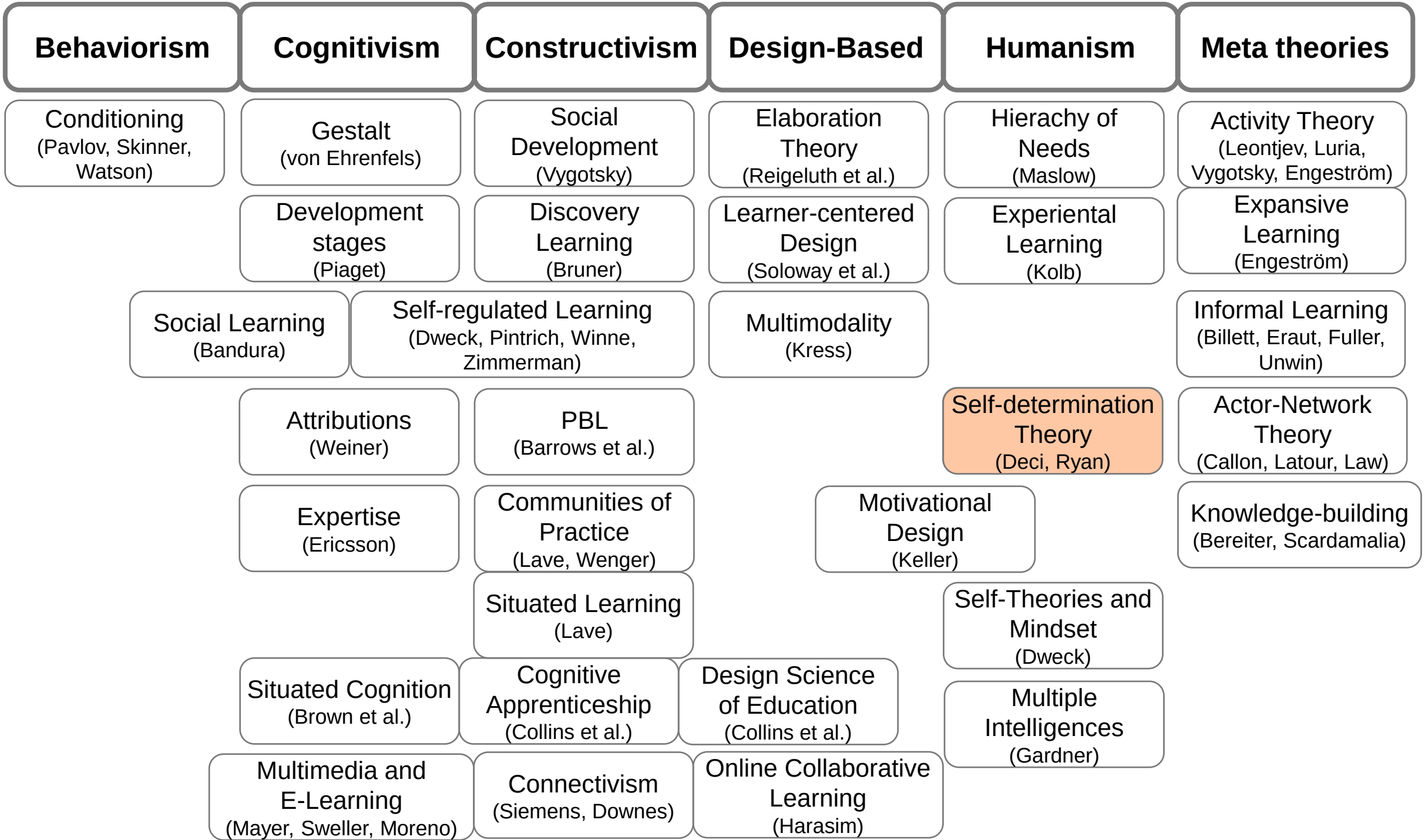
Final grade (0 – 100%)



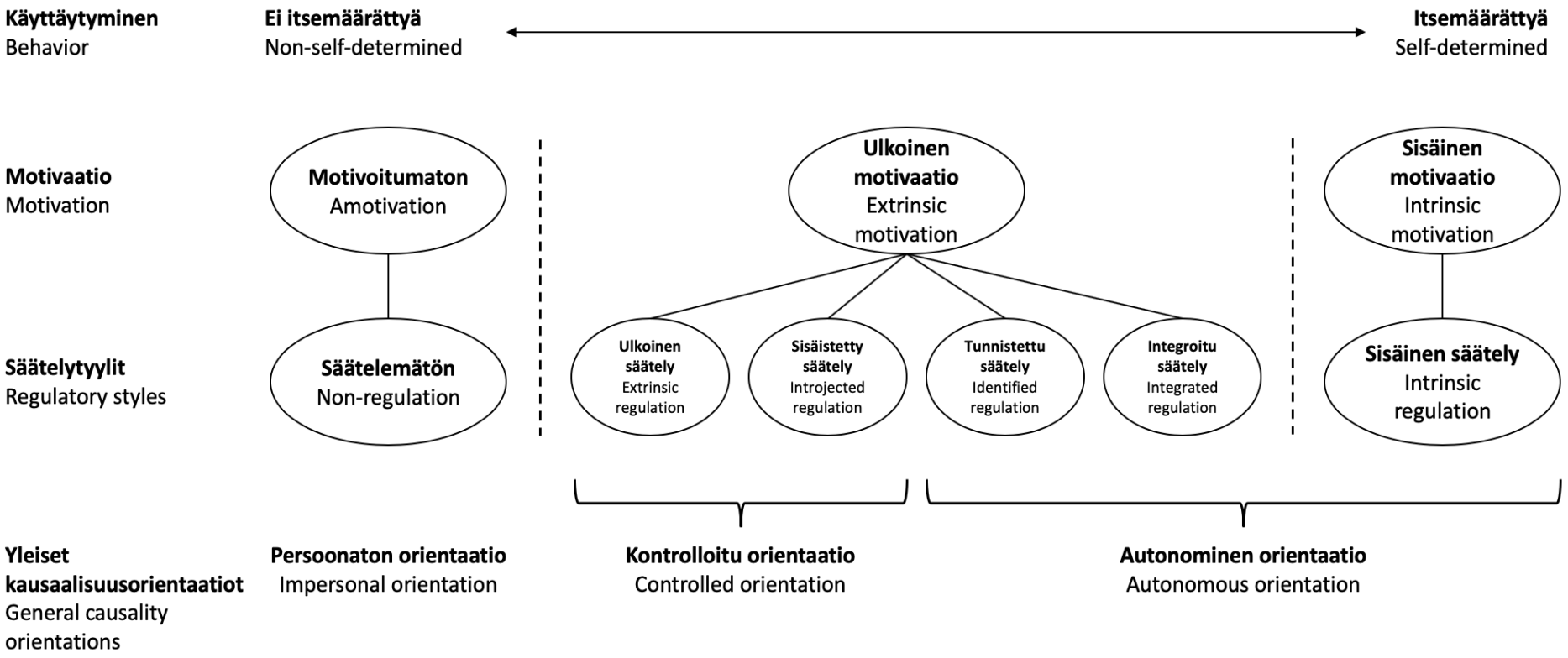
Shared exam score (0 – 100%)



[a] After controlling for the pretest


Behaviorism
Cognitivism
Constructivism
Design-Based
Humanism
Meta theories
Conditioning (Pavlov, Skinner, Watson)
Gestalt (von Ehrenfels)
Social Development (Vygotsky)
Elaboration Theory (Reigeluth et al.)
Hierachy of Needs (Maslow)
Activity Theory (Leontjev, Luria, Vygotsky, Engeström)
Development stages (Piaget)
Discovery Learning (Bruner)
Learner-centered Design (Soloway et al.)
Experiental Learning (Kolb)
Expansive Learning (Engeström)
Social Learning (Bandura)
Self-regulated Learning (Dweck, Pintrich, Winne, Zimmerman)
Multimodality (Kress)
Informal Learning (Billett, Eraut, Fuller, Unwin)
Attributions (Weiner)
PBL (Barrows et al.)
Self-determination Theory (Deci, Ryan)
Actor-Network Theory (Callon, Latour, Law)
Expertise (Ericsson)
Communities of Practice (Lave, Wenger)
Motivational Design (Keller)
Knowledge-building (Bereiter, Scardamalia)
Situated Learning (Lave)
Self-Theories and Mindset (Dweck)
Situated Cognition (Brown et al.)
Cognitive Apprenticeship (Collins et al.)
Design Science of Education (Collins et al.)
Multiple Intelligences (Gardner)
Multimedia and E-Learning (Mayer, Sweller, Moreno)
Connectivism (Siemens, Downes)
Online Collaborative Learning (Harasim)

Self-determination theory



Kuvio 1. Opiskelun itseohjautuvuus autonomisen, kontrolloidun ja persoonattoman orientaation mukaan (Nokelainen, 2019, muokattu Ryan & Deci, 2000, p. 72)

(Nokelainen, 2019, muokattu Ryan & Deci, 2017, p. 193)

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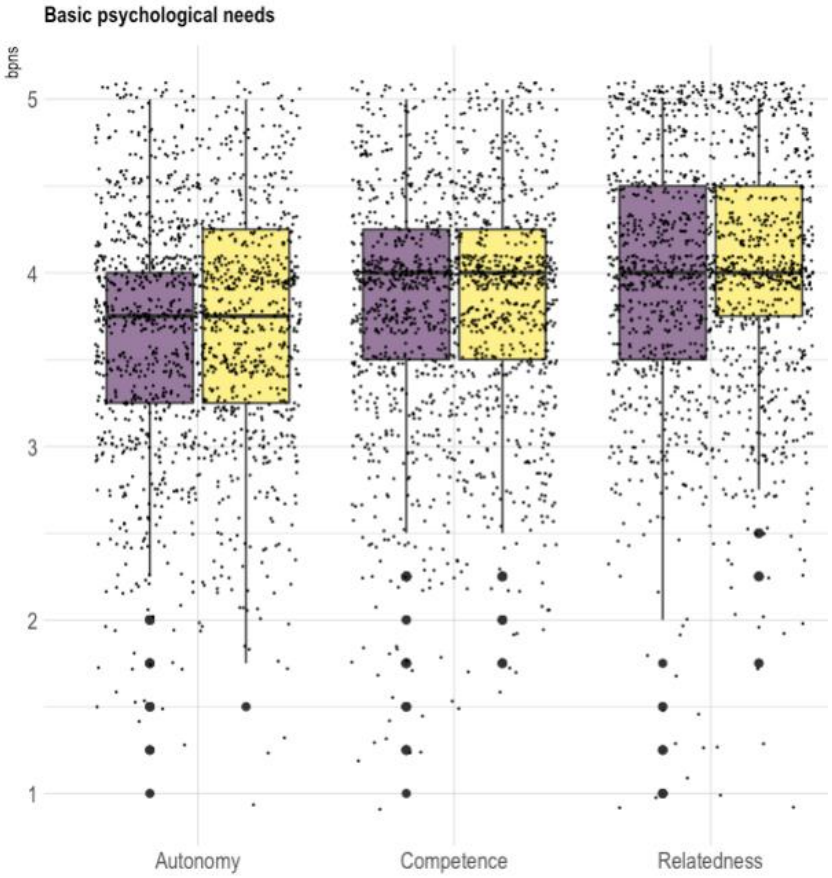
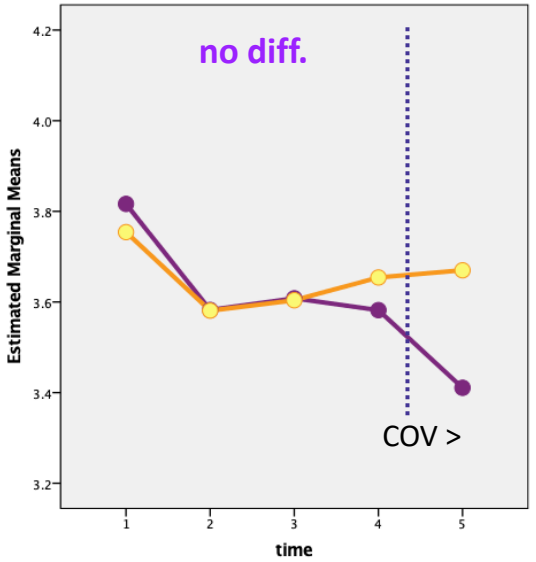
How pedagogical implementation (Trad/Flip) is related to the development of students' **basic psychological need satisfaction** (autonomy, competence, relatedness)?



Traditional teaching group (*n* = 216)

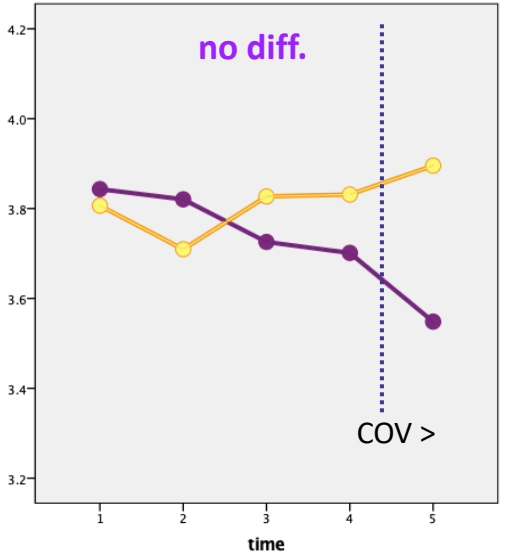
Flipped teaching group (*n* = 189)

Autonomy



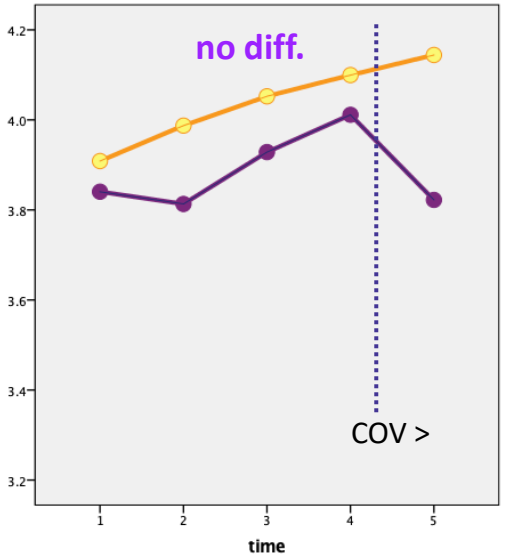
Sample item:
"In my studies, I feel a sense of choice and freedom in the things I undertake."

Competence



Sample item:
"I feel confident that I can do things well in my studies."

Relatedness

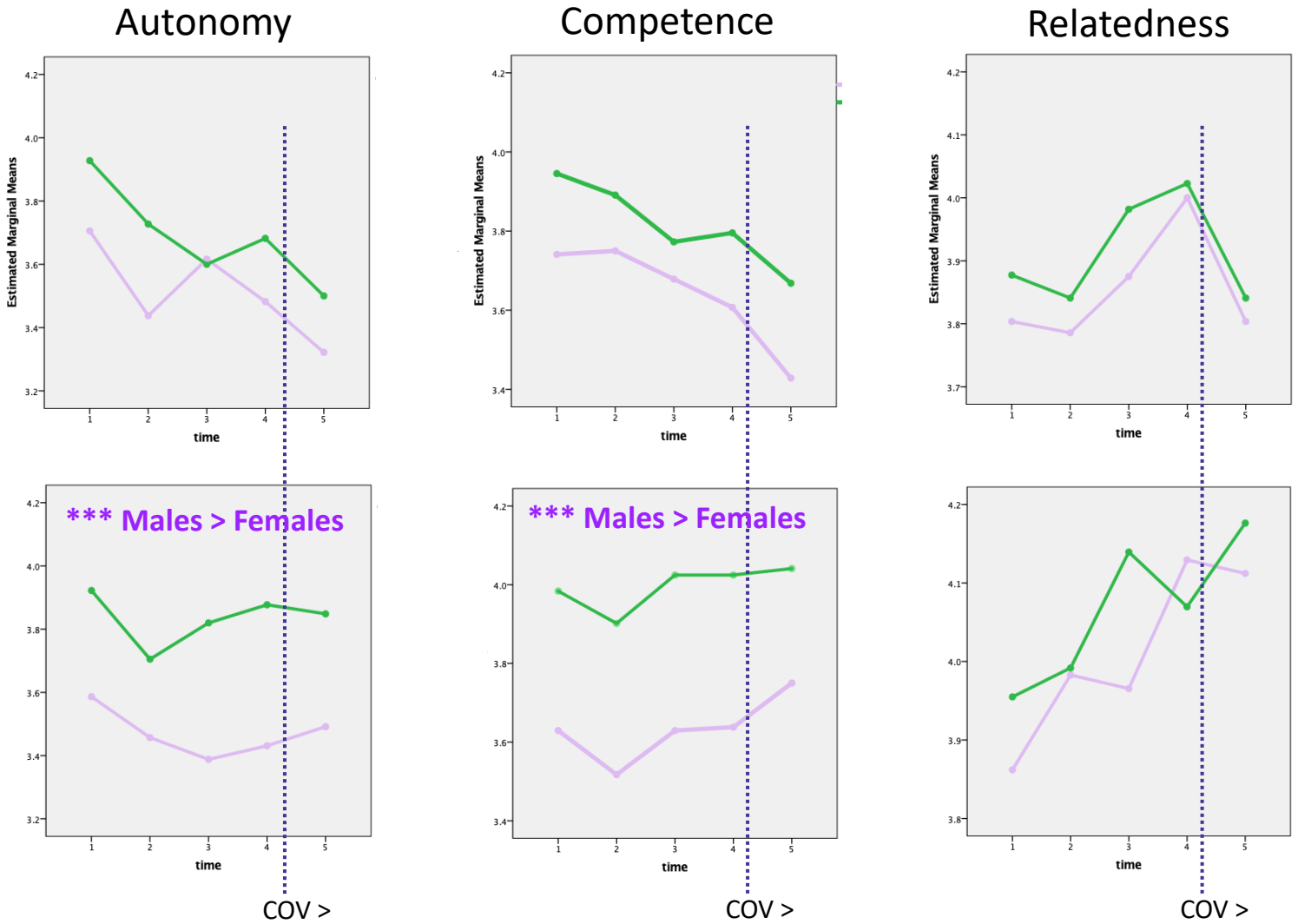


Sample item:
"I feel that the people I care at the university about also care about me."

How pedagogical implementation (Trad/Flip) is related to the development of **female** and **male** students' **basic psychological need satisfaction** (autonomy, competence, relatedness)?

Traditional

Flipped



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Thank you!

MathFlip research team:

Technology-Enhanced Mathematics Teaching (TTMOT) research group

- Terhi Kaarakka, Simo Ali-Löytty, Jani Hirvonen, Riikka Kangaslampi, Johanna Rämö, Elina Viro, Vikke Vuorenpää

Professional Growth and Learning (PGL) research group

- Petri Nokelainen, Susanna Hartikainen, Essi Saario, Jenni Piirto, Ilmari Puhakka, Eija Lehtonen, Tiia Lehtinen

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Visit also Teaching and Learning Centre: https://www.tuni.fi/tlc