ELTE | TTK
TERMÉSZETTUDOMÁNYI KAR

Gamification of Introductory University Physics Courses

Szabolcs Varga and Péter Jenei

KULTURÁLIS ÉS INNOVÁCIÓS MINISZTÉRIUM

THE PROJECT WAS REALIZED WITH THE SUPPORT OF THE MINISTRY OF CULTURE AND INNOVATION FROM THE NATIONAL RESEARCH, DEVELOPMENT AND INNOVATION FUND, FINANCED BY THE KDP-2023 GRANT PROGRAM.

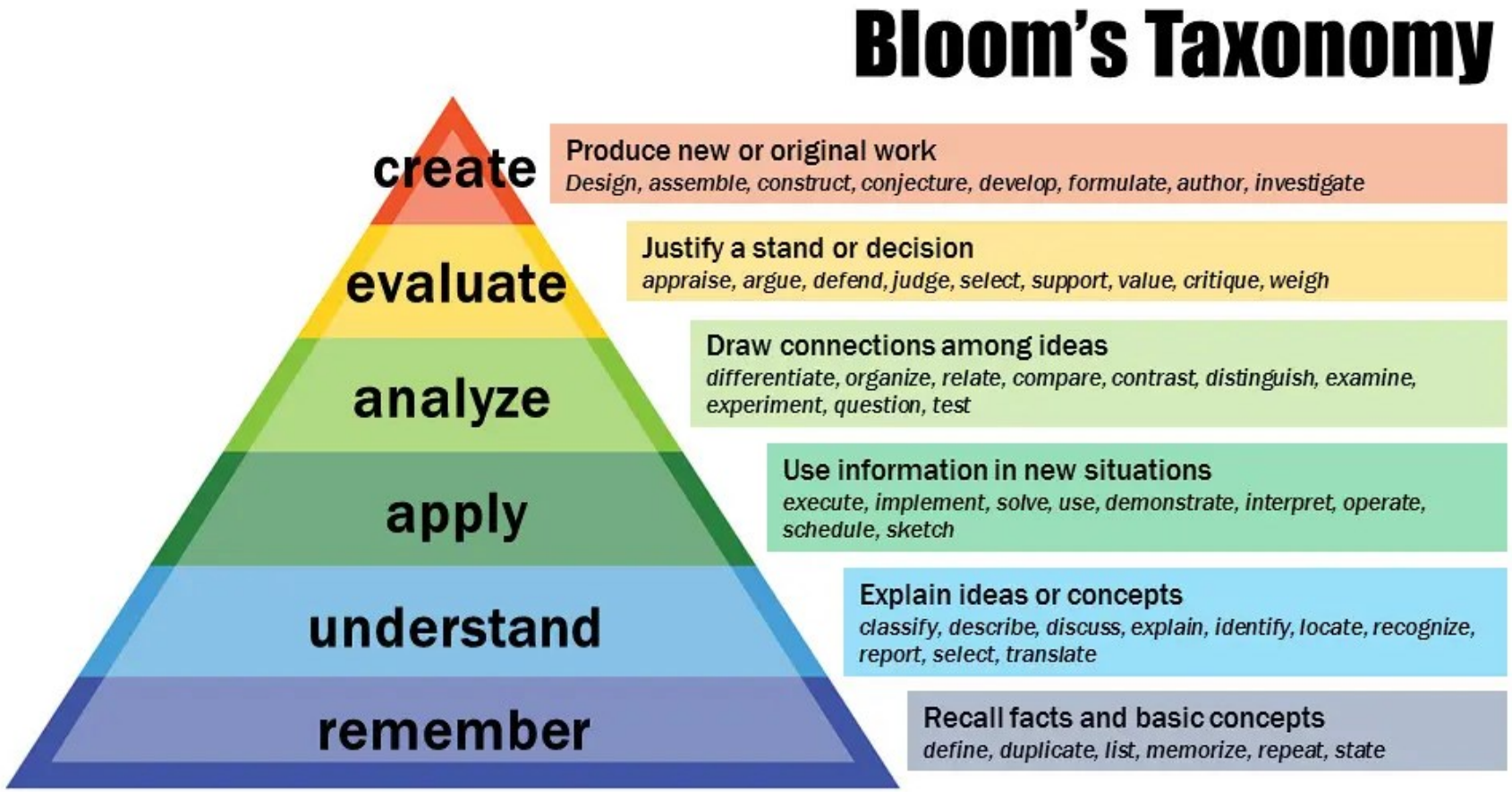
Introduction to Gamification

- **Gamification:** the process of improving an activity by creating the opportunity for game-like experiences to encourage user value creation.
- **Key elements in the educational process:**
  - Well-structured course, learning support interface
  - **Points system:** students are rewarded for their activities
  - Optional and varied tasks
- **1990s, Anglo-Saxon education:** from elementary level to university
  - Raising and maintaining interest
  - A system that has been working in the advertising industry for decades

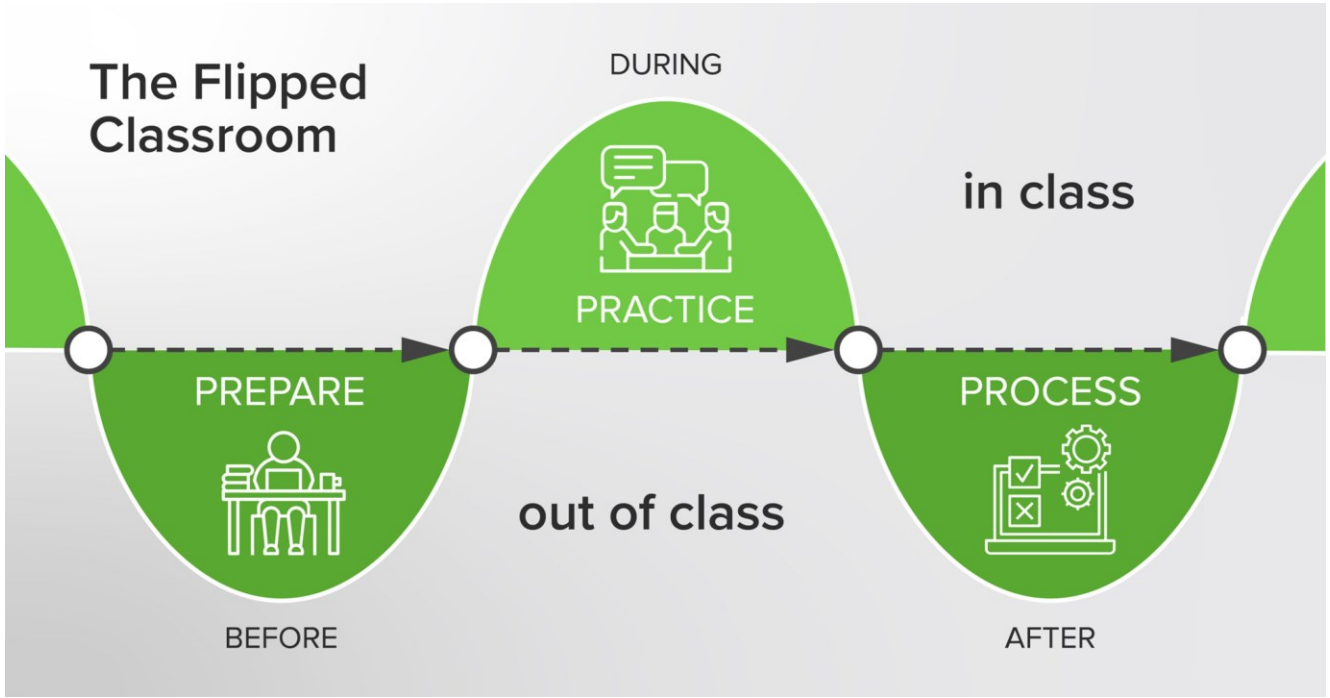
Introduction to flipped classroom

- **Flipped classroom:** direct instruction is moved outside of the classroom, and class time is used for interactive, hands-on activities and deeper learning
  - It reverses the traditional teaching process.
  - Theoretical material is acquired at home, independently.
  - Classroom time is dedicated to problem-solving and clarifying questions under the teacher's guidance.
- **Bloom's Taxonomy:** a hierarchical framework that classifies educational learning objectives into different levels of complexity and specificity, ranging from basic recall to complex evaluation and creation.

The theoretical basis of methods aimed at student engagement and differentiated learning



Elements for implementing methods aimed at student engagement and differentiated learning



The concept of the educational experiment

- Selected course: **Mechanics - basic level**
  - Students: Physics teacher students and Physics students who performed poorly on the entry test
  - Instructors: Péter Ispánovity, Péter Jenei
- The curriculum of the experimental course:
  - Foundations of classical mechanics
  - Description of motion and its causes
  - The motion of rigid bodies
- The aim: demonstrate how gamification and the flipped classroom can be effectively applied in the Hungarian higher education environment

Hypotheses

- **The professional knowledge** of students learning with innovative methods **is at a higher level** than that of students learning with classical methods (without an increase in instructor workload).
- **The professional development** of students learning with innovative methods **is greater** than that of those participating in classical education.
- **The knowledge** of students learning with innovative methods **is more lasting** than that of those learning according to classical methodology.
- **The commitment** of students learning with innovative methods **is greater**, because of which they achieve better learning outcomes in the higher years as well.

The transformation of the course

- Materials prepared **at home** by the students
  - 20–30-minute instructional **videos** (board explanations, demonstration experiments)
  - Written **notes** (core material and supplements)
  - **Quizzes** focusing on the elements necessary for advancement
  - **Forums** for emerging questions
- Materials related to **in-class** activities
  - **Control questions** and **explanations** for the material already covered
  - **Problem sets**: computational tasks, measurement tasks
  - Experiment design, modeling, simulation, explanation, discussion
  - **Quizzes** related to the in-class activities

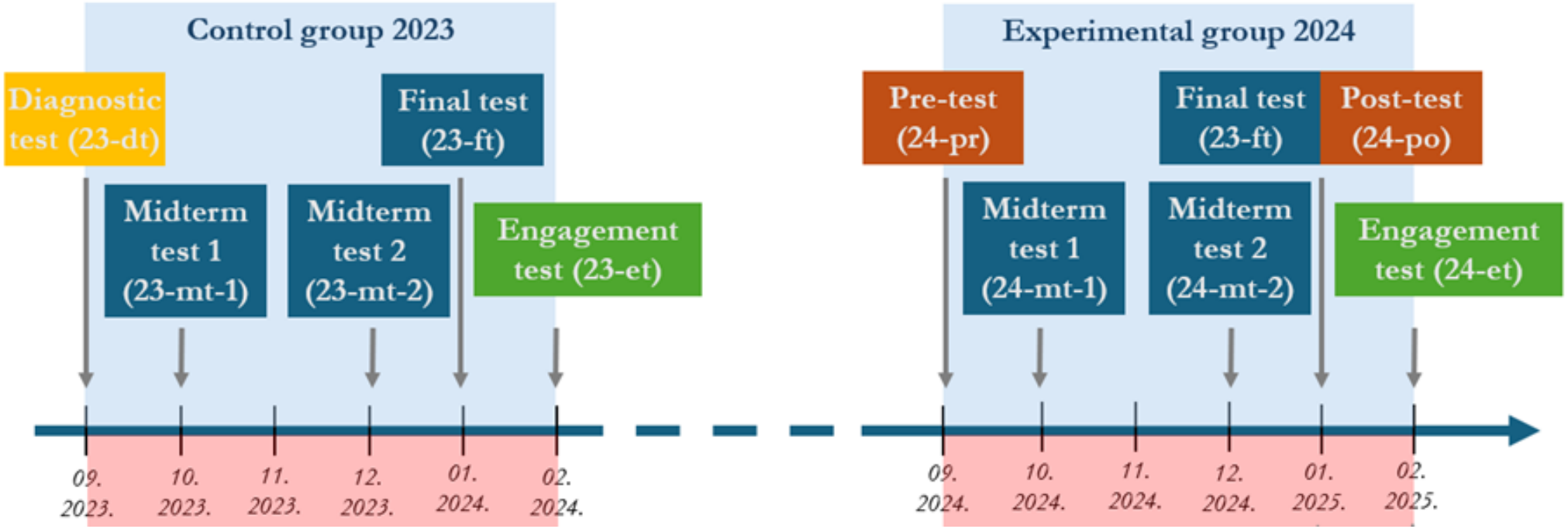
Evaluation of students

- Basis: points and **point collection** - this makes up the semester grade
  - Points from at-home and in-class quizzes
  - Two midterm exams during the semester
  - Final exam at the end of the semester
  - Project task in groups (investigation and presentation of a selected problem)
  - Opportunity for improvement: oral exam
- Supplement: **badges**
  - Hard skills: excellent presenter, excellent problem-solver, …
  - Soft skills: excellent team player, excellent critical thinker, …

Various student activities in the light of gamification and the flipped classroom

Flipped classroom	Before class	During class	After class
Gamification elements	Remember, understand	Apply, analize	Evaluate, create
Personalization	*Professional notes*	*Check-up questions*	*Project tasks*
Levels, challenges	*Tutorial videos*	*Problem sets*	*Reports*
Points, badges	*Quizzes*	*Experiments*	*Assignments*
Cooperation	*Forums*	*Team competitions*	*Peer instructions*

The timeline of the educational experiment

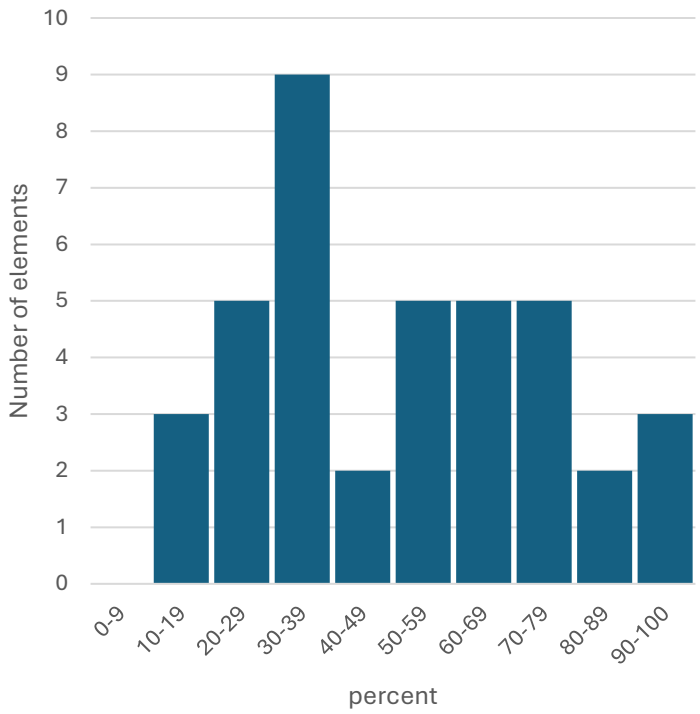


The results of the first midterm test

	Control group (2023)	Experimental group (2024)
number of elements	39	39
mean	**52,564**	**62,564**
standard deviation	23,700	21,971
p of independent simple t-test (significance)	0,057 **No significant difference**	

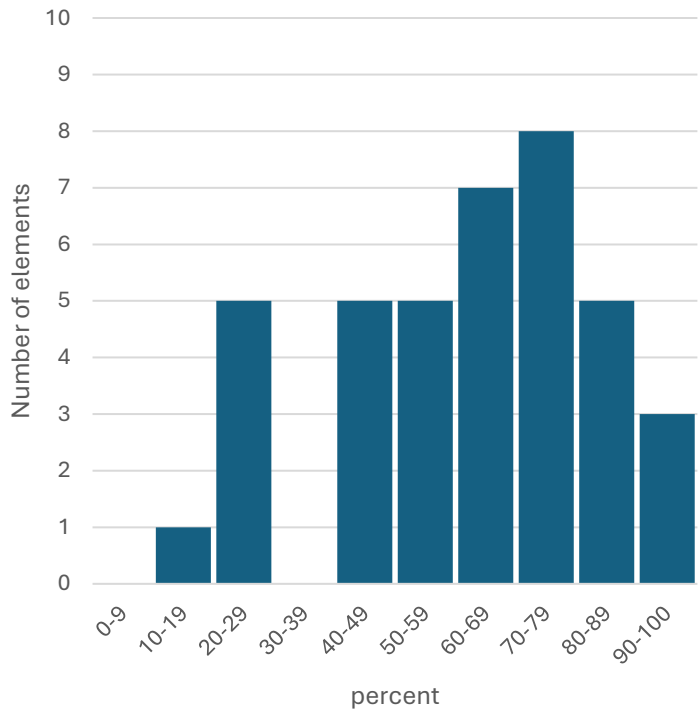
The results of the first midterm test

2023



Under 40%: 17
Above 80%: 5

2024



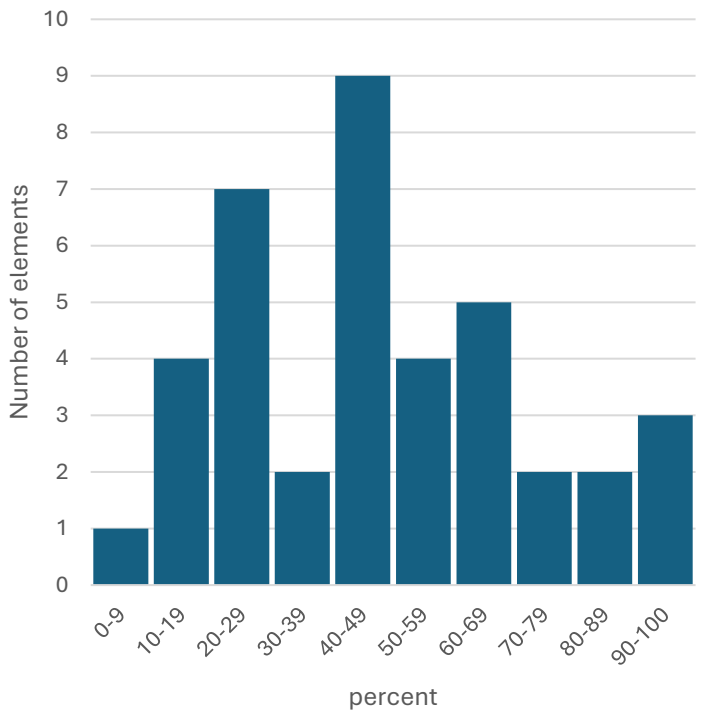
Under: 40%: 6
Above 80%: 8

The results of the second midterm test

	Control group (2023)	Experimental group (2024)
number of elements	39	37
mean	**49,372**	**60,513**
standard deviation	24,867	22,079
p of Mann Whitney (significance)	0,049 **There is a significant difference**	

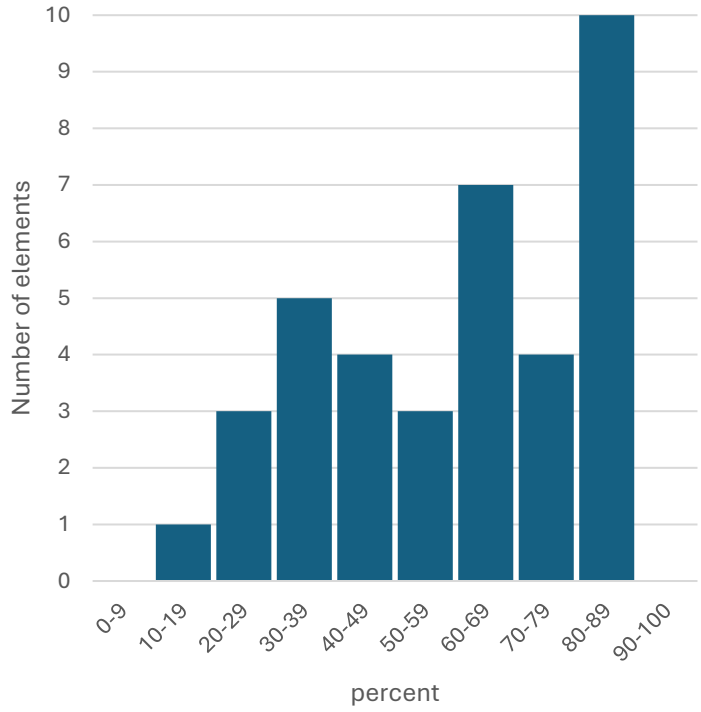
The results of the second midterm test

2023



Under 40%: 13
Above 80%: 5

2024



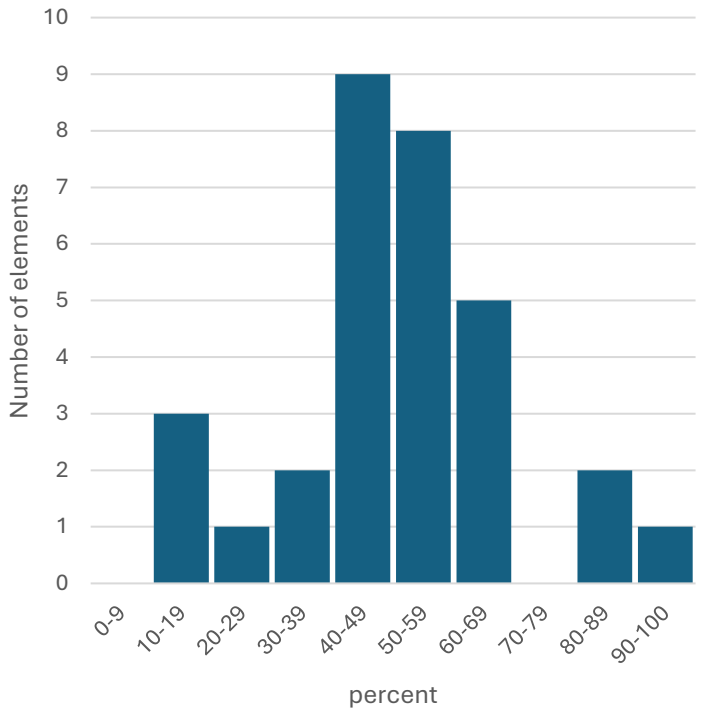
Under 40%: 9
Above 80%: 10

The results of the final test

	Control group (2023)	Experimental group (2024)
number of elements	31	27
mean	**52,065**	**79,106**
standard deviation	20,090	16,196
p of Mann Whitney (significance)	<0,01 **There is a significant difference**	

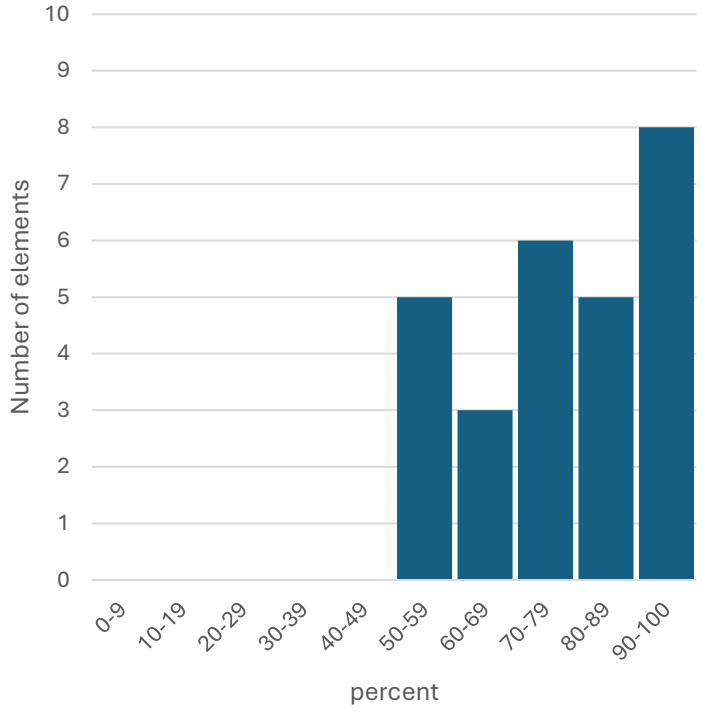
The results of the second final test

2023



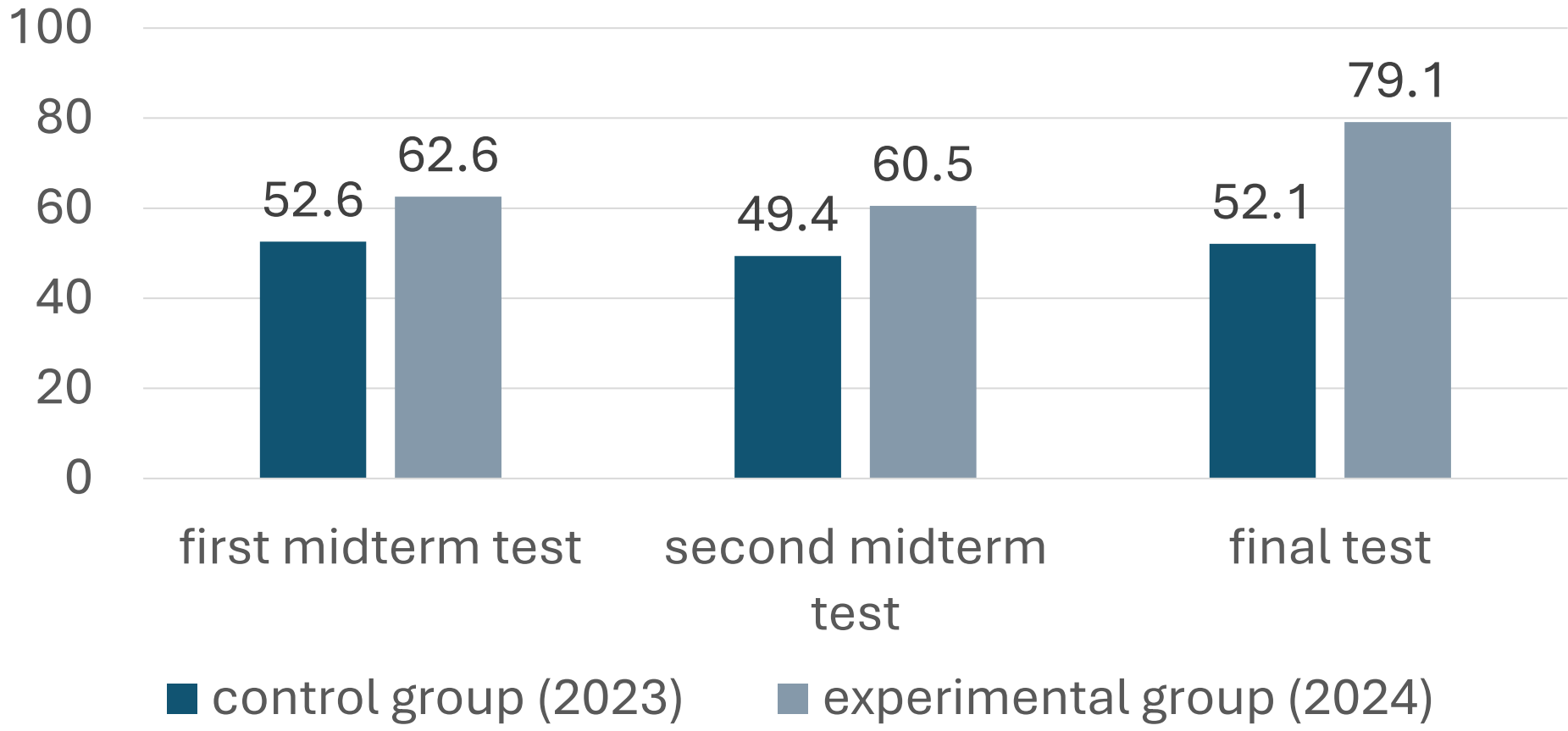
Under 40%: 6
Above 80%: 3

2024



Under 40%: 0
Above 80%: 13

Summary of the results



Interviews with the students - positiv

Curriculum and Course Structure:

- A reform-oriented approach that is innovative and interactive.
- The effectiveness of experiments and practical tasks.
- Professionally formulated course materials.
- Optional tasks and choices.

Support for the learning process:

- Placing practical elements and experimentation in the foreground.
- The motivating effect of a points-based system.
- The usefulness of quiz-based tasks.
- The possibility of processing theoretical materials at home (videos and text).
- The goal is knowledge, not grade acquisition.

Interviews with the students - negativ

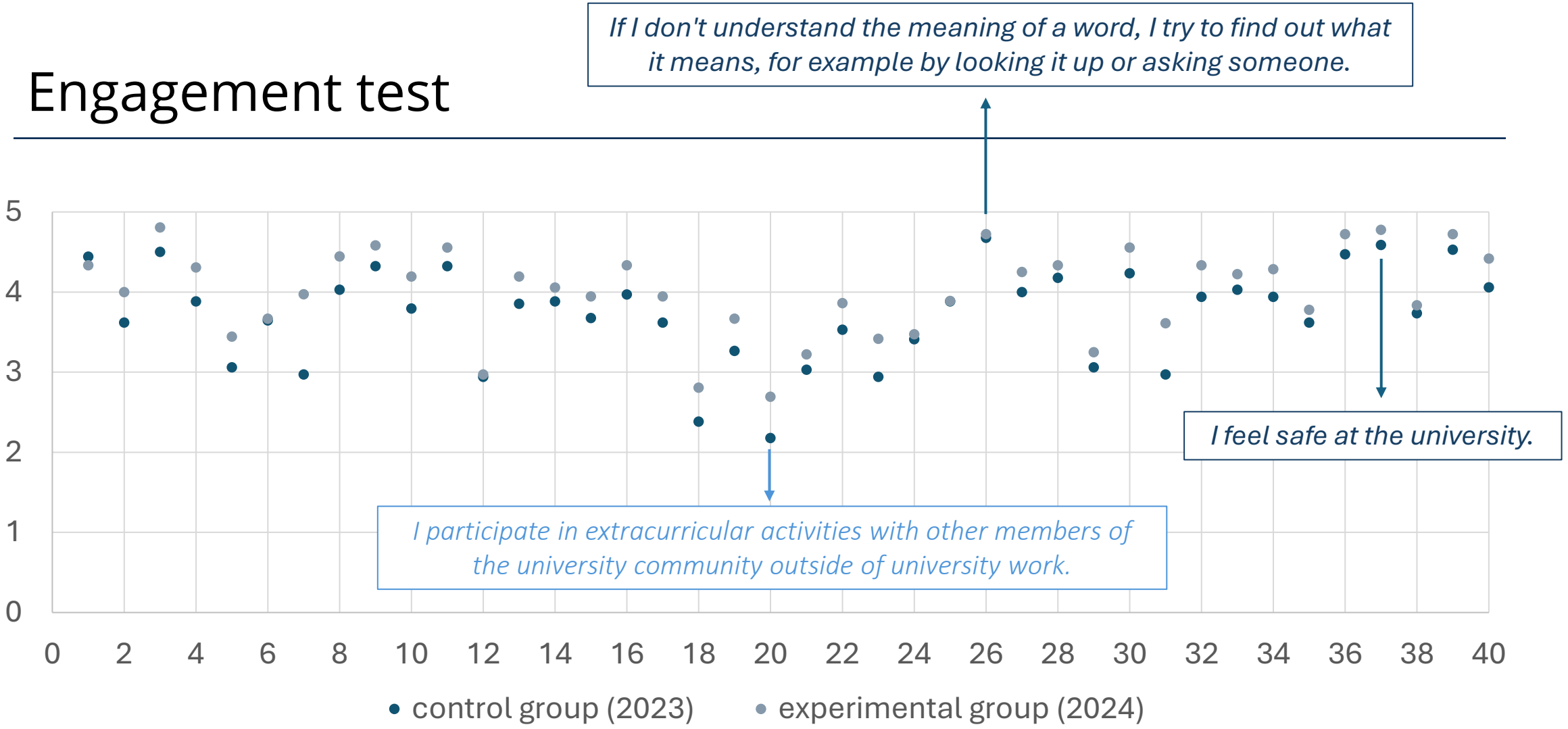
Group Work:

- Different knowledge levels and communication difficulties hinder effectiveness.
- Some students find the frequency of group work to be excessive.
- Random team assignment causes dynamic problems.

Time and Workload:

- The optional tasks are time-consuming and do not always fit into the students' schedules.
- The 9 credits cause difficulties in coordination with other subjects.

Engagement test



Plans for the future

- Further analysis and publication of data
- Involving additional courses in the experiment
- Incorporating further gamification elements into the mechanics course
- Extending the method to secondary and primary education.

Thank you for your attention.