Learning by app

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Studying Mobile

A Comenius Leadership Fellow program at Leiden University (2019-2023)

Applicant: dr. Ludo Juurlink

> *associate professor Physical Chemistry at Leiden Institute of Chemistry*
>
> *Research group: Catalysis and Surface Science*
>
> *Research fields #1: Surface Science and Chemical reaction dynamics*
>
> *Research fields #2: Chemical pedagogy and mobile learning*

Co-applicants: prof. dr. Han de Winde (Biology)

prof. dr. Marco de Ruiter (Medicine)

dr. Maarten van de Ven (ICLON)

The hurdle race

1. Lack of insight into its structure makes an academic curriculum to its students look like as a series of more or less unrelated courses and assignments (hurdles).

2. Financial incentives make students want to study efficiently.

➔ Many students adopt studying techniques that are efficient in passing assessments but inefficient in building long-term retention, e.g. 'cramming'.
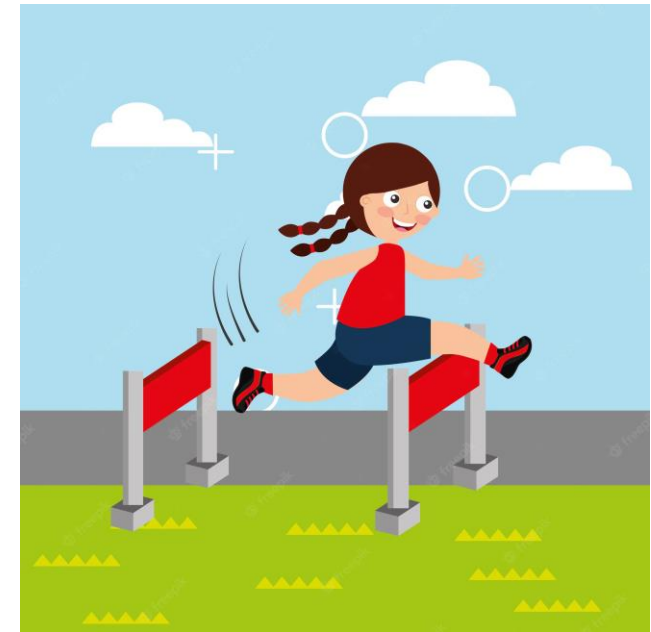
Cerego

a mobile phone-based application that uses push technology to remind students to study at *the optimal time*.

Cerego's engine uses

- distributed learning (spaced repetition)
- retrieval practice (testing effect)

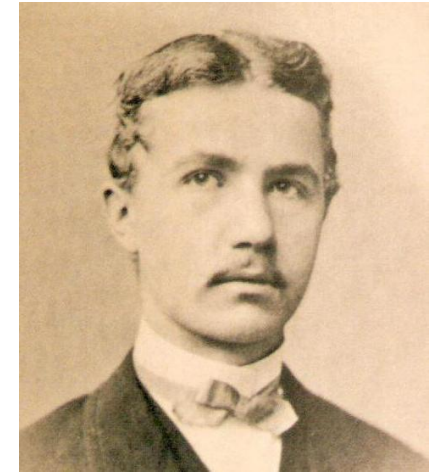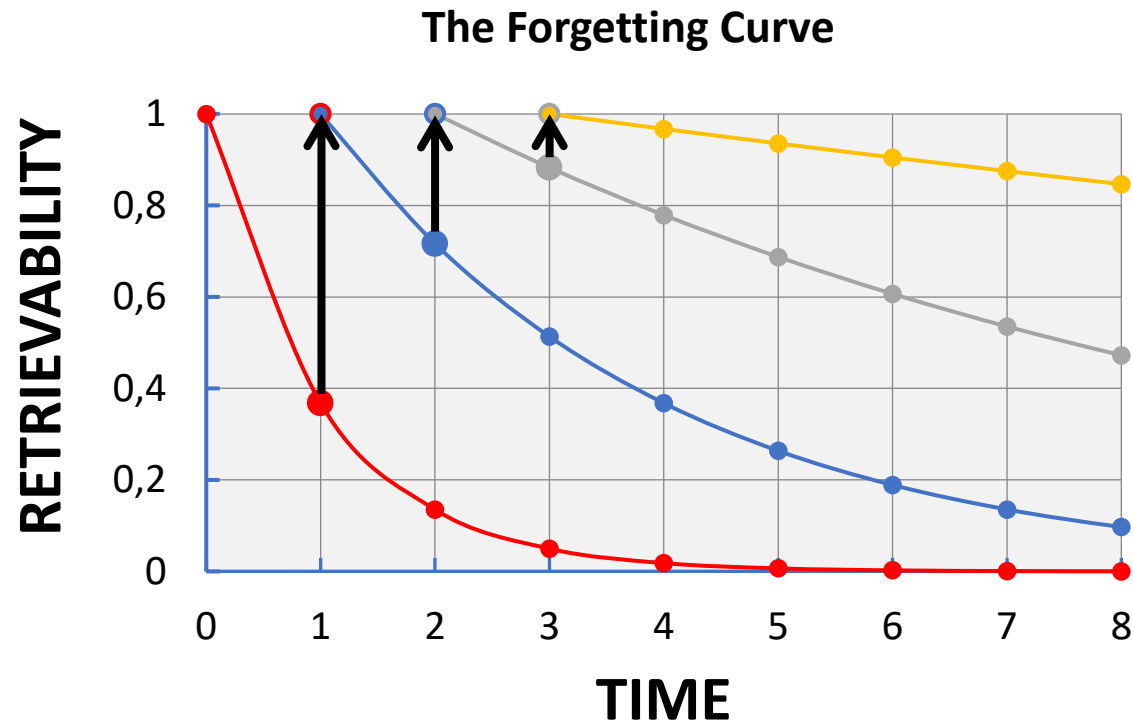and

- it adapts itself to each individual student
- can be integrated with, a.o., Brightspace
- runs on all smart phones
- is reasonably affordable

"Adaptive learning platform"

Distributed learning

The Forgetting Curve

Hermann Ebbinghaus
1850 - 1909

$$R = e^{-t/s}$$

Retrievability

Stability of memory

aka "Spaced repetition"

Retrieval practice

"The finding that taking a test on previously studied material leads to better retention than does restudying that material for an equivalent amount of time."
APA Dictionary of Psychology

aka "Testing effect", "active recall", ..

ON THE ANALYSIS OF THE FACTOR OF RECALL
IN THE LEARNING PROCESS.

BY EDWINA E. ABBOTT.

CONTENTS.

I. THE NATURE AND AIM OF THE PROBLEM.

No one who has had experience in memorizing or in watching others memorize can have failed to observe the tendency of the average person when he is reading, to momentarily turn away from the material before him and to repeat it to himself

How does it work?

1. Professor (or student assistant) creates content, e.g. flash cards, ordering assignments, clickable images, … in "sets" that can be studied in rather short study sessions.

2. Sets are added to a "course".
- Retention level
- Availability (start and end date/gated)

3. Student signs up for your course and receives notifications to study the material.

The first time they see/read everything in a new set.
Thereafter, they are only tested to build retention.

They continue to study throughout the course while an AI algorithm tracks each student performance and optimizes parameters (*what* and *when*).

What we suggested to study

1. "Implementation effects", e.g.
   a) How easily is a platform like this implemented?
   b) Do students appreciate the availability of the platform?

2. Whether the use of Cerego affects long-term retention   main pedagogical issue

3. Whether it lowers test anxiety

   side issues

4. Whether it increased time spent studying

What have we learned so far? part 1a

2019-2022   **Logistics of implementation**

1 AVG/GDPR issues

2 The difficulty of convincing others to get involved (both teachers and support)
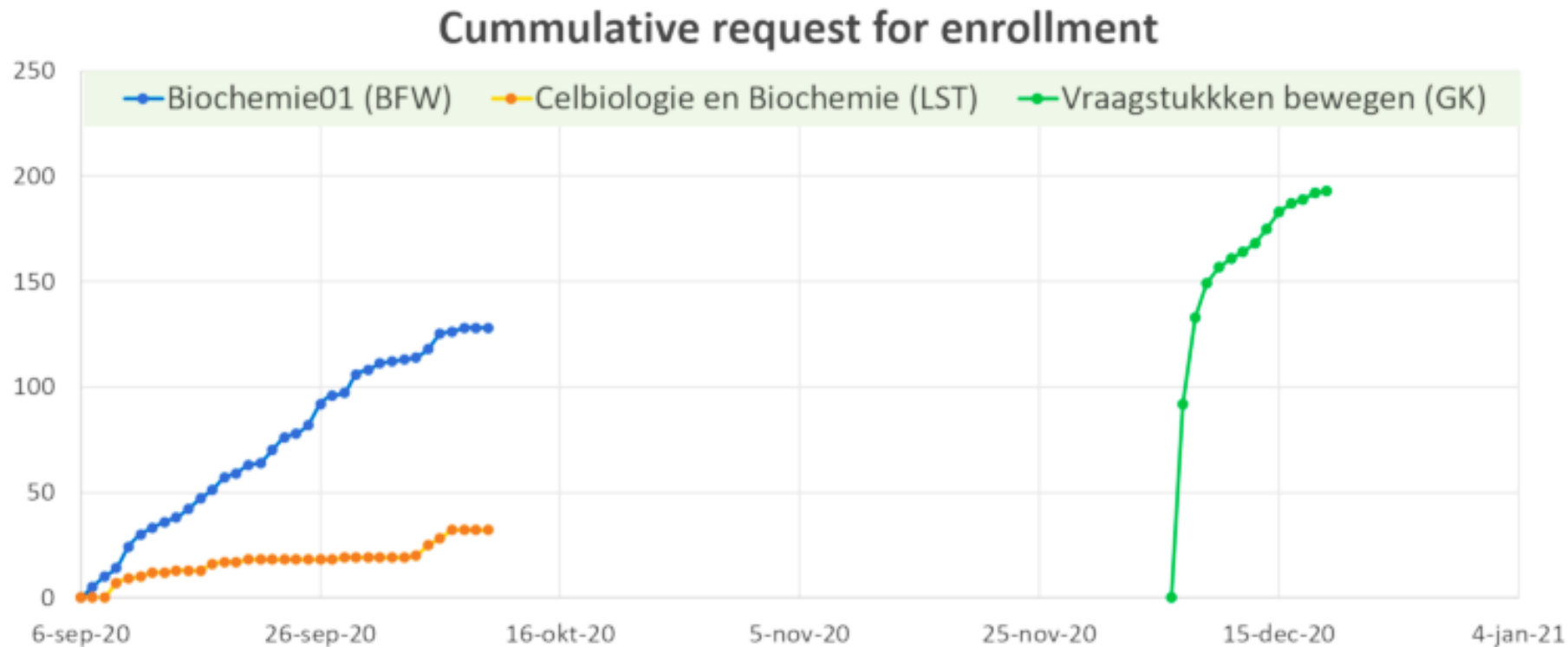
3 Funding to pay for continuation of license

4 Training of teachers and student assistants
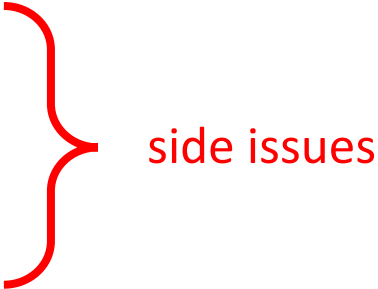
What have we learned so far? part 1a

Monitor *date of registration* for Cerego as an optional study tool.

Cummulative request for enrollment

→ Technology acceptance varies between programs?!

What we suggested to study

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What have we learned so far? part 1b

Student experience tested through *30 second SURVEY* at 5 different programs (Dec-2020).
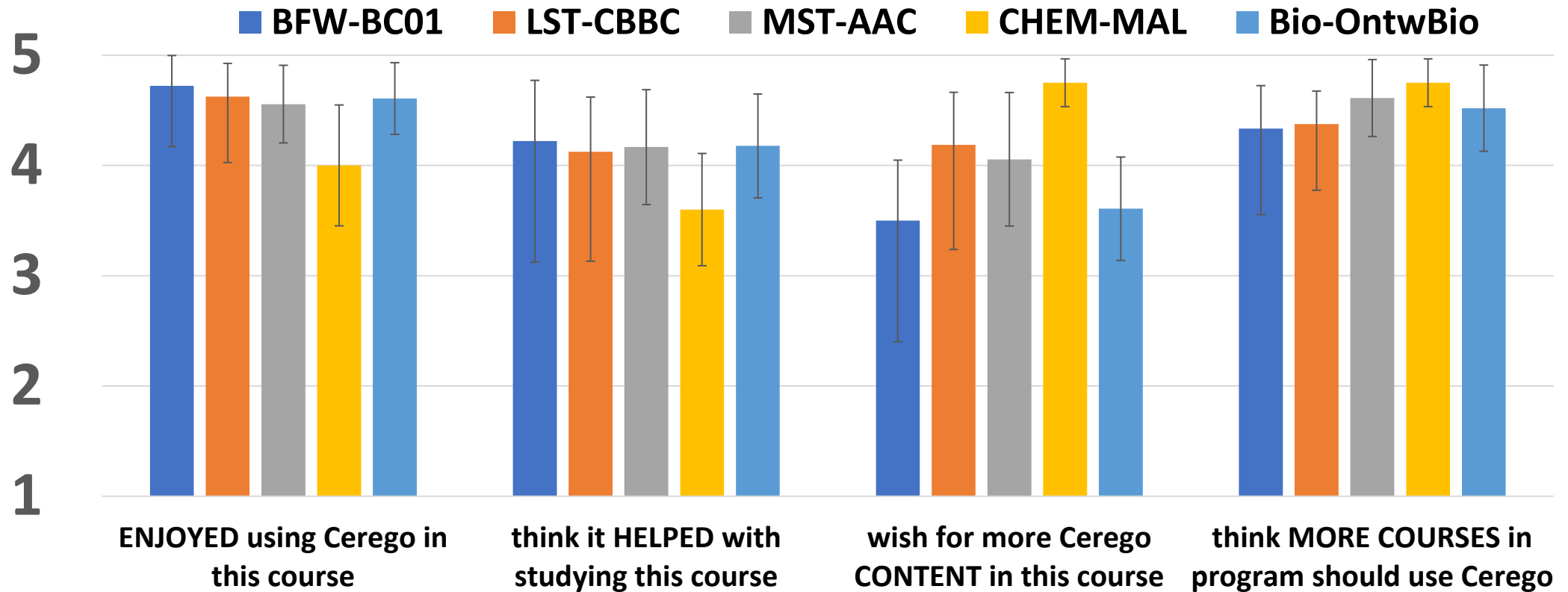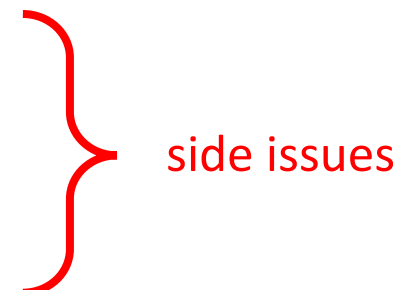
What have we learned so far?   part 1b

Student experience tested through *general SURVEY* after "Anatomy - Motion" (March 2021), N ~300.

Likert scale van "slecht" (1) tot "zeer goed" (5)

- De Cerego app is een fijne aanvulling voor het leren van de anatomische structuren, av. = 4,7.
- De Cerego app is een aanvulling op het bestaande onderwijs, av. = 4,6.
- Ik zou de Cerego app aanbevelen aan medestudenten, av. = 4,7.
- De Cerego app was gebruiksvriendelijk, av. = 4,5.
- Ik vond het fijn dat Cerego aangeboden werd als extra studiemiddel bij Vraagstukken Bewegen, av. = 4,8.
- Ik denk dat het studeren via Cerego me heeft geholpen bij Vraagstukken Bewegen, av. = 4,6.
- Ik had graag méér studiemateriaal aangeboden gekregen via Cerego bij Vraagstukken Bewegen, av. = 4,4.
- Het zou goed zijn als studeren met Cerego bij méér vakken van mijn opleiding wordt aangeboden, av. = 4,8.

What we suggested to study

1. "Implementation effects", e.g.
   a) How easily is a platform like this implemented?
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What have we learned so far?   part 2

2019-2022   **Learning Effects**

Testing for retention effects within BSc Chemistry program.
Involved courses "General Chemistry" (Q1, yr 1) and "Inorganic Chemistry" (Q4, yr 1)

"General Chemistry" (Q1, yr 1)
- 6 EC taught in 8 weeks + 2 weeks (Sept-Nov)
- Enrollment ~180 students
- Classes and 'workshops'
- Content based on a teacher-written book
- Midterm and a final exams
- Cerego use is optional
- Cerego content mostly serves topics leading up to the midterm exam.

"Inorganic Chemistry" (Q4, yr 1)
- 6 EC taught in 8 weeks + 2 weeks (April-July)
- Enrollment ~140 students
- Classes and 'workshops'
- Content based on a commercial book
- *Repeats and elaborates on of some of the topics form General Chemistry.*

➔ **Entrance level (retention) test is useful in itself**

What have we learned so far?   part 2

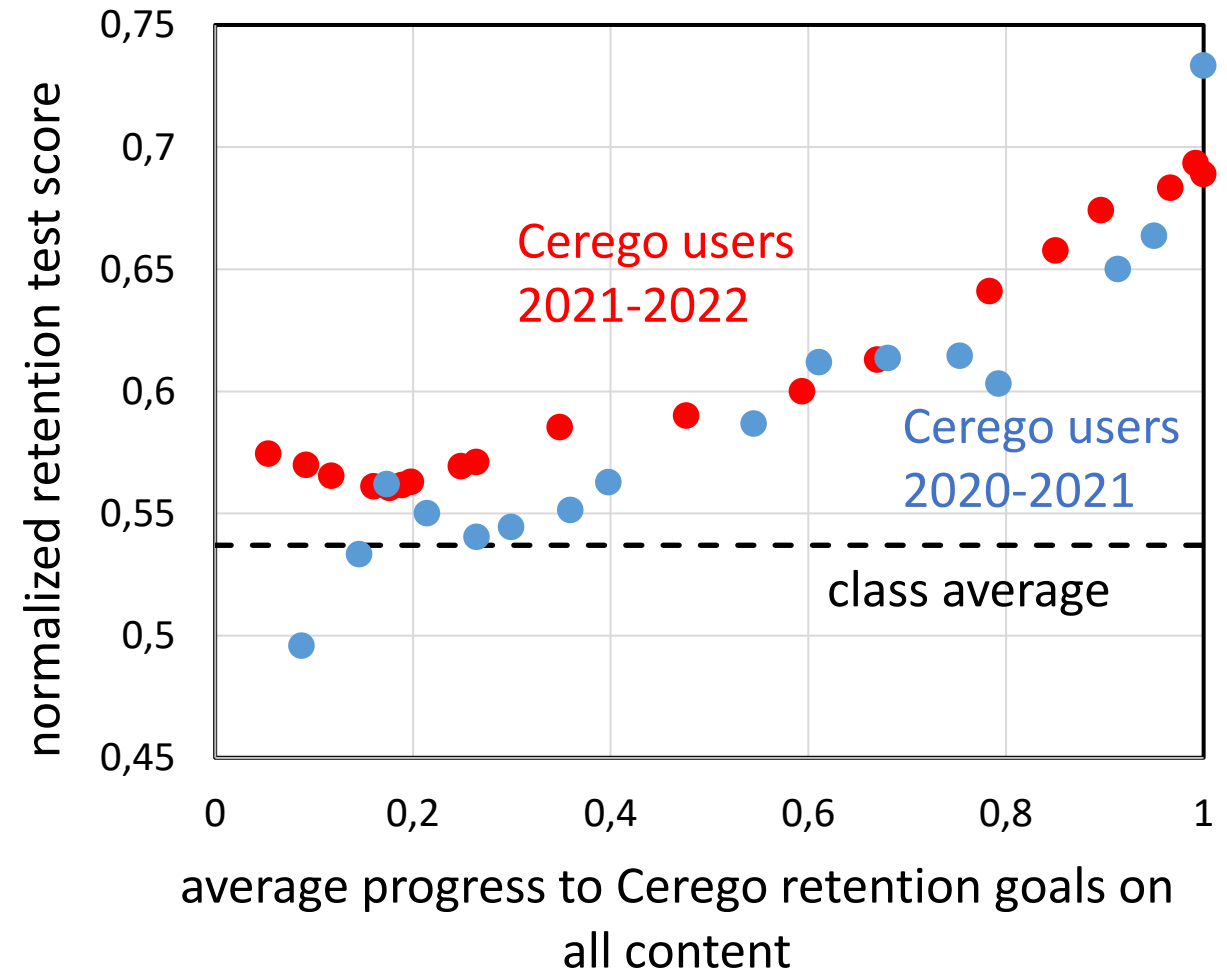**Retention test characteristics**

- Voluntary but unannounced
- 30 questions offered sequentially in *random order* in a *BrightSpace quiz*:
    - 21 questions relate to study material also offered within Cerego during "General Chemistry"
    - 9 questions did not have Cerego-related content
- Grading: 1 or 0 points per question
- Timed: 15 minutes max

- Question types:
    - 3 multiple answer (3 in Cerego-related questions + 0 in non-related)
    - 17 multiple choice (15+2)
    - 8 true/false (2+6)   ← note this potential for bias!
    - 2 ordering (1+1)

What have we learned so far? part 2

2021-2022

- *N* = 102 students

- 134 of these also registered for Cerego when taking AAC
  - 51 did not start // 83 started
  - 23 reached > 50% progress goals

- Same general observations in both years
  - Cerego users score higher.
  - Scores increases with reached study goal in Cerego

Cerego users 2021-2022

Cerego users 2020-2021

class average

normalized retention test score

average progress to Cerego retention goals on all content

What have we learned so far?   part 2

2020-2021

- Focus on **non-Cerego related questions**

Question #	Question	Discrimination index (%)	Average score	Average score Cerego users	Average score non-users
22	HF is een sterk zuur.	43,8	0,375	**0,405**	0,370
24	De geconjugeerde base van een zuur met een K_a waarde...	56,1	0,441	**0,514**	0,395
28	In de kristalveldtheorie staat het symbool Δ_o..	53,1	0,475	**0,676**	0,383

What have we learned so far?   part 2

2020-2021

- Compared AAC exam results

Exam #	Average score Cerego users	Average score non-users
1	79,6	63,1
2	59,6	42,8

Relies in part directly on content also offered within Cerego

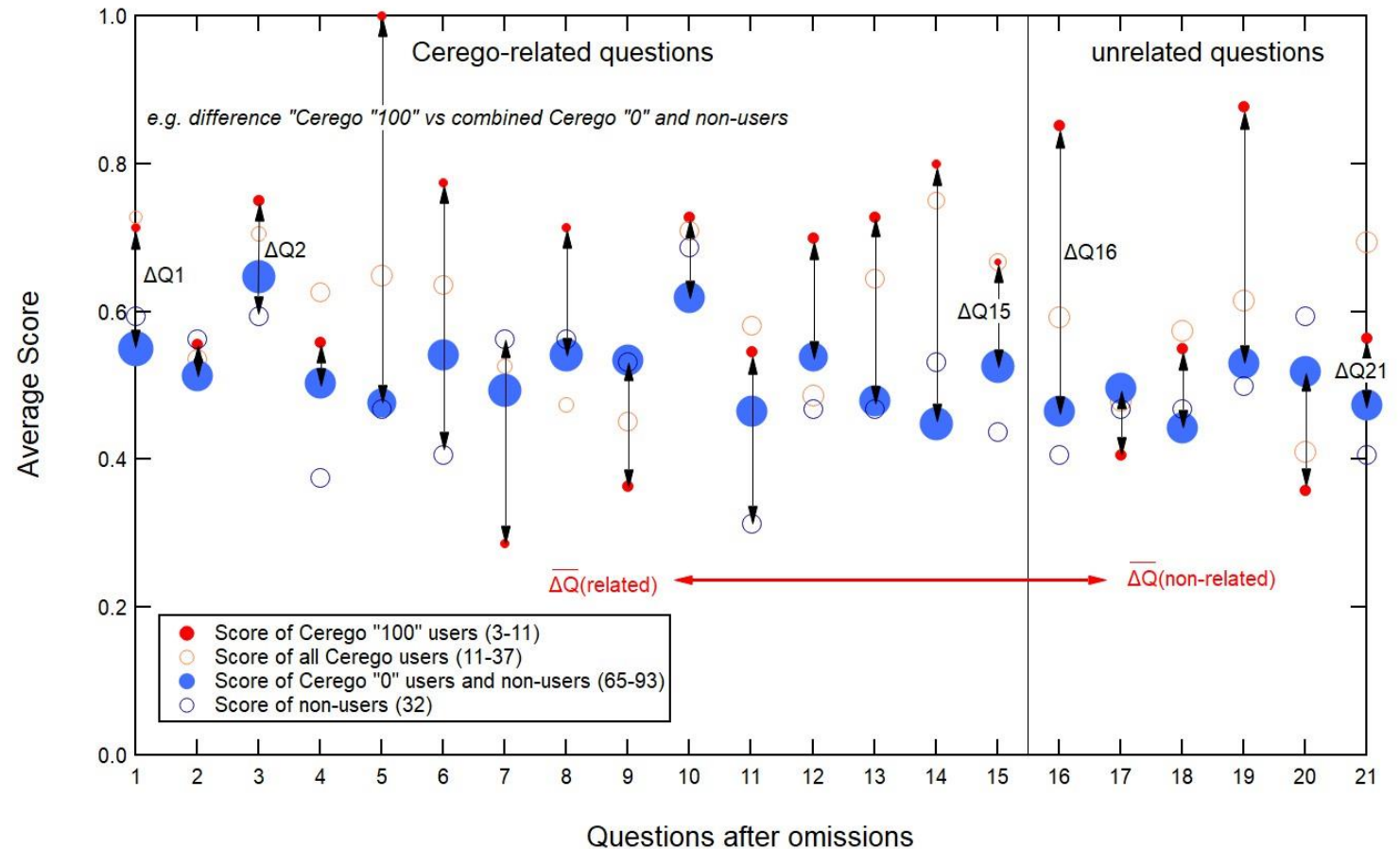**Does not rely directly** on content also offered within Cerego

➔ **Selection bias and/or compound effect?!**

What have we learned so far?   part 2

2021-2022

- Analyze results *in detail*:

- *Conclusion*: Avid Cerego users clearly do better (about 20% for the most avid users) on the retention test, but this is likely due to a selection bias and/or compound learning effect.

What have we learned so far?   part 2

2021-2022

- Alternate comparison to remove the selection bias

Design:

- **Compare performance of Cerego students with course progress > 50% to an equal sized group with identical results on AAC Final exam scores (exam2).** *These exam results can not reflect Cerego study effects as no questions were asked that related to Cerego study content.*

- We compare scores on all and the selected 21 questions of the retention test administered after 5 months.

What have we learned so far?   part 2

2021-2022

- Alternate comparison

Average score AAC Final = 6.43
StDev = 2.10

Average score AAC Final = 6.39
StDev = 2.17

AAC score final	Cerego progress	AAC score final	Cerego progress
10	96%	10	24%
9,53	98%	9,29	n.a.
8,82	99%	8,82	4%
8,35	68%	8,24	4%
8,35	55%	8,24	0%
7,65	55%	7,77	n.a.
7,06	60%	7,06	42%
6,71	73%	6,71	5%
6,12	99%	6,18	n.a.
6	52%	6	n.a.
5,65	79%	5,71	0%
5,65	54%	5,65	n.a.
5,59	99%	5,59	24%
5,24	51%	5,53	n.a.
4,77	53%	4,77	33%
4,53	82%	4,47	n.a.
4	61%	4,06	n.a.
1,77	91%	1	7%

What have we learned so far?   part 2

2021-2022

- Alternate comparison

- *Observation*: From two identical groups, "Avid Cerego users" (here defined as scoring >50% on Cerego-defined learning goals)) score considerably better than others after 5 months on the retention test.
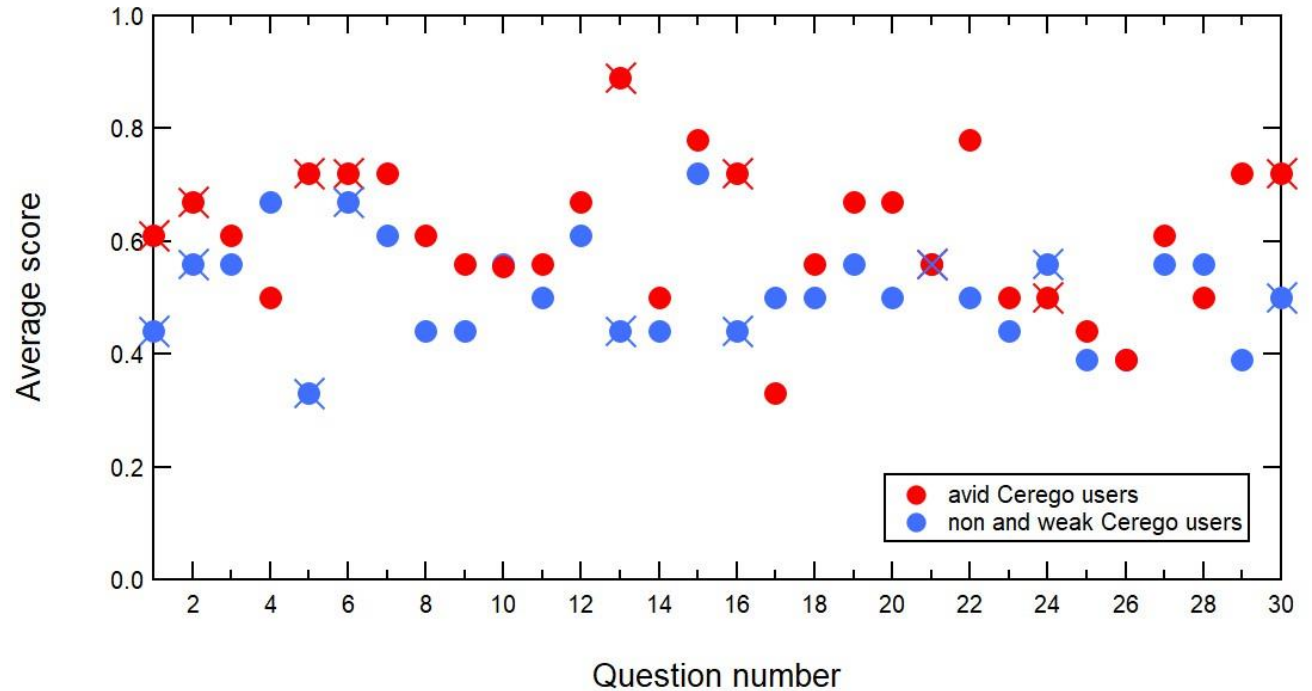

	Score "avid Cerego users"	Score "non/poor Cerego users"	Cerego improvement
complete test (30 questions)	18.3	15.3	+20%
limited test (21 questions)	12.2	10.8	+13%

What have we learned so far?   part 2

2021-2022

- Many more comparison groups (500 per data point) using two varying intervals
  - AAC final exam score interval
  - Cerego learning goal cut off

- *Observation*: From two identical groups, "Avid Cerego users" score considerably better than others after 5 months. This is especially so for users of Cerego exceeding 50% of the learning goals.
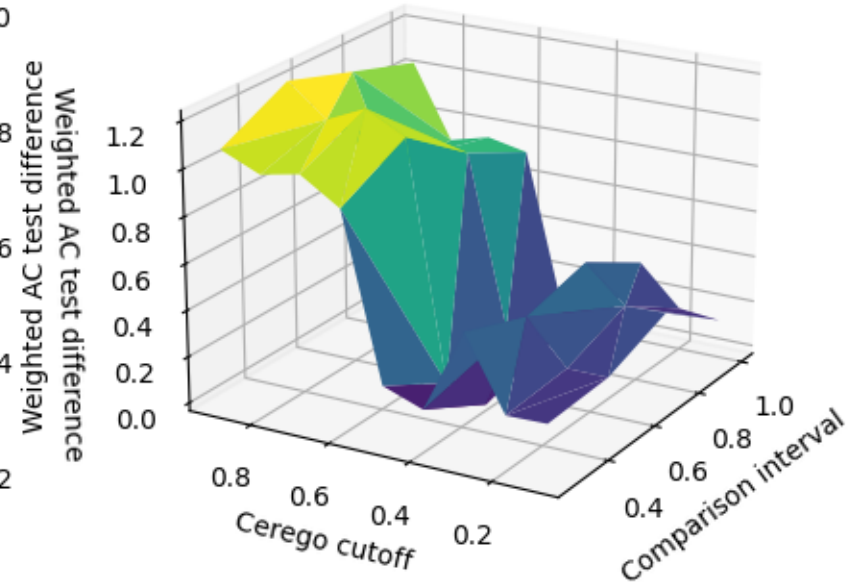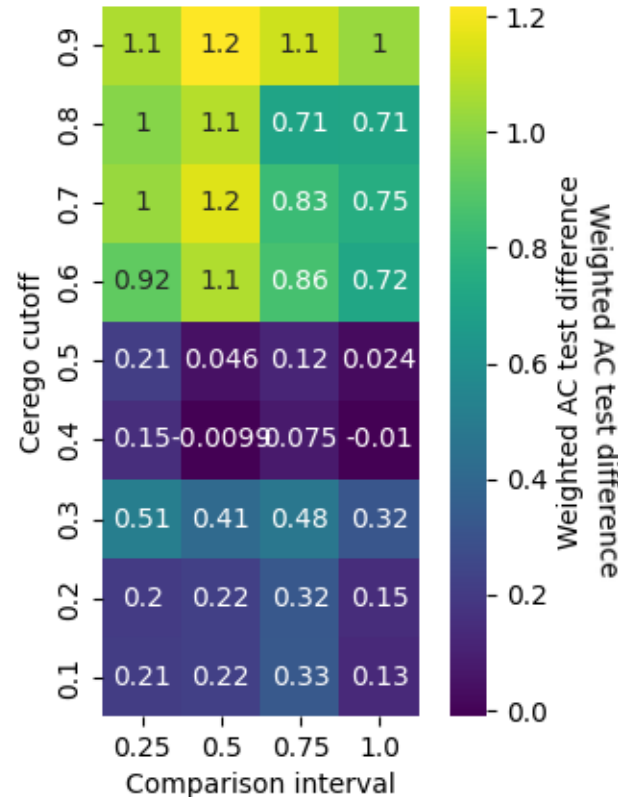
Started with implementation in Summer 2019

2019-2020

1 Introductory Chemistry (BSc Molecular Science & Technology/*Maths & Natural Sciences*)
2 Anatomy (Medicine/*LUMC*)
3 Material Science (BSc Archeology/*Archeology*)

Added in 2020-2021:

4 Celbiology and Biochemistry (BSc Life Science & Technology/Maths & Natural Sciences)
5 Biochemistry 1 (BSc Biopharmaceutical Sciences/Maths & Natural Sciences)
6 Metals and Life (MSc Chemistry/Maths & Natural Sciences)
7 Introductory in programming in Python (BSc Computer Science/Maths & Natural Sciences)
8 Developmental Biology (BSc Biology/Maths & Natural Sciences)
9 Introductory Chemistry (BSc Biopharmaceutical Sciences/Maths &Natural Sci
…

In April 2022:
1700 active users
2700 registered users

Sept 2022: Vocabulary building (BSc Law, *Faculty of Law*) + 1200 potential students!

Conclusions

Implementation

1. GDPR issues, license costs, and the limited period of a pilot study negatively affect implementation.

2. Students and teachers are very positive about the availability

3. *Technology acceptance variation* between programs is likely affecting the intended outcome (better long-term retention).

Learning effects

1. Strong indications of a selection bias and/or compound effect in retention data.

2. Circumventing the selection bias, we find a positive effect on long-term retention (~10% improvement for avid Cerego users over a 5-month time span).

Een gewilde app waarmee je beter leert!

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