Where Learning Analytics and Artificial Intelligence Meet: Hybrid Human AI-Regulation

Dr. Inge Molenaar
SOLAR
14 December

Behavioural Science Institute

Adaptive Learning Lab
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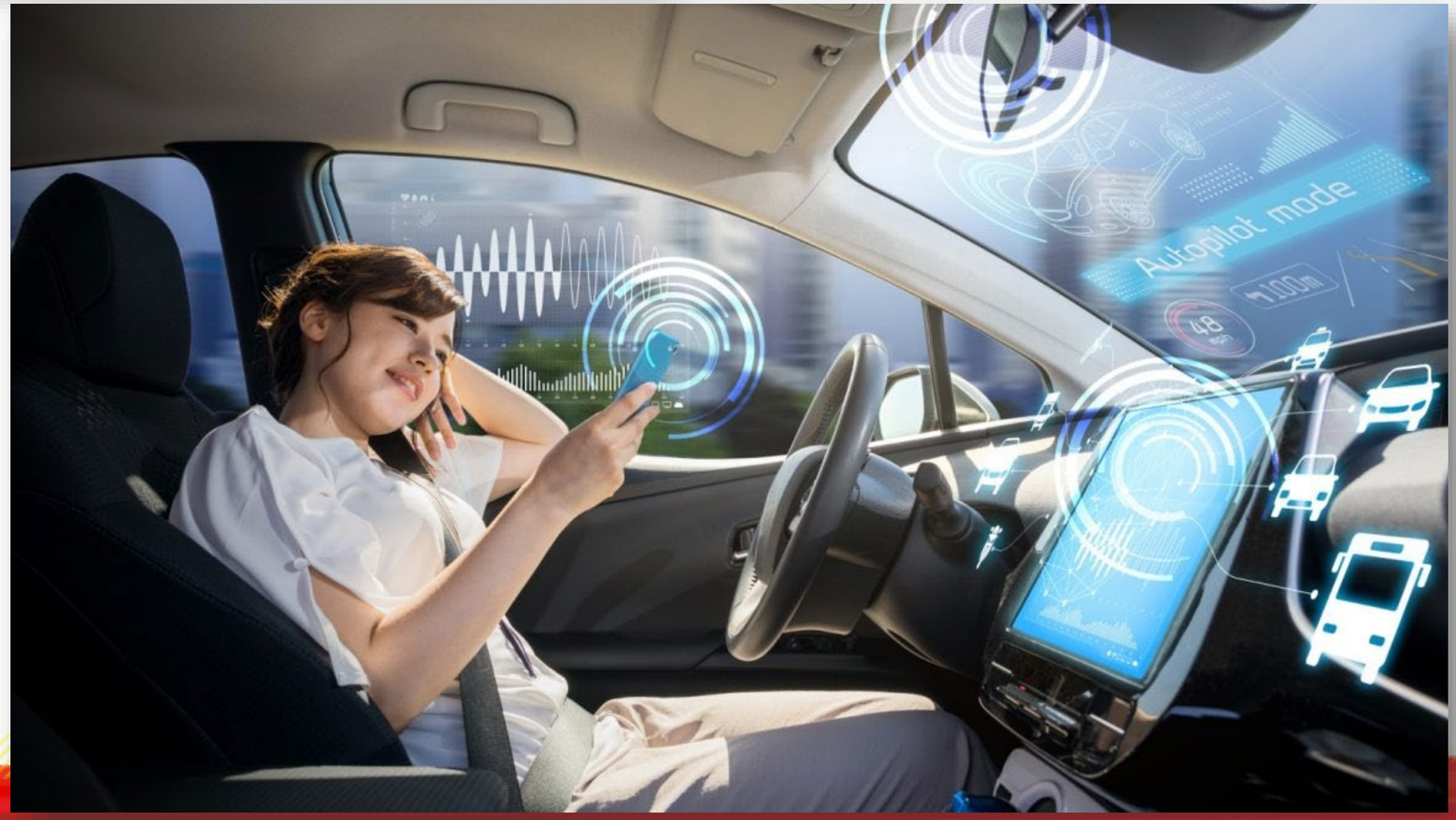
This Talk

- How to conceptualize AI in relation to human learning?
- Theoretical Framing
- Empirical underlayers
  - Measurement of SRL
  - Support of SRL
- Toward Hybrid Human-AI Regulation


Autopilot mode

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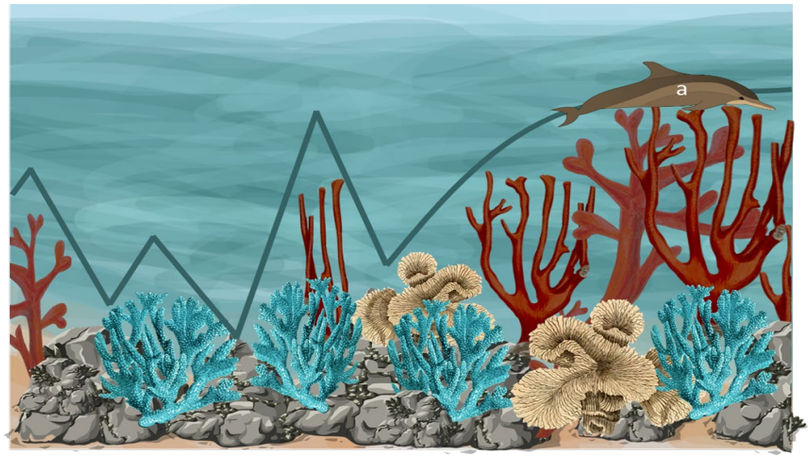
Offload Regulation

WHY: Onload Regulation

1. Deep Learning
2. Future learning

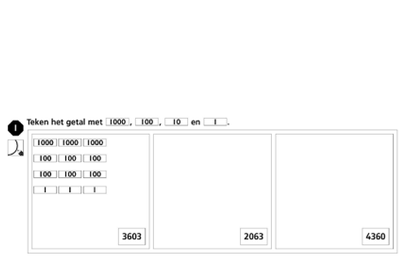
Concept: Hybrid Human-AI Regulation

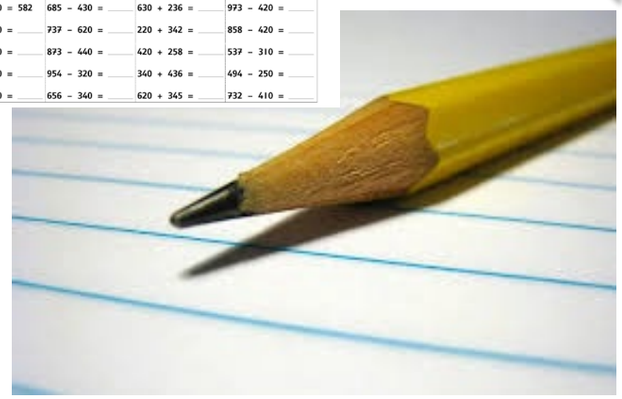
Hybrid Human-AI Regulation: Transfer of Control

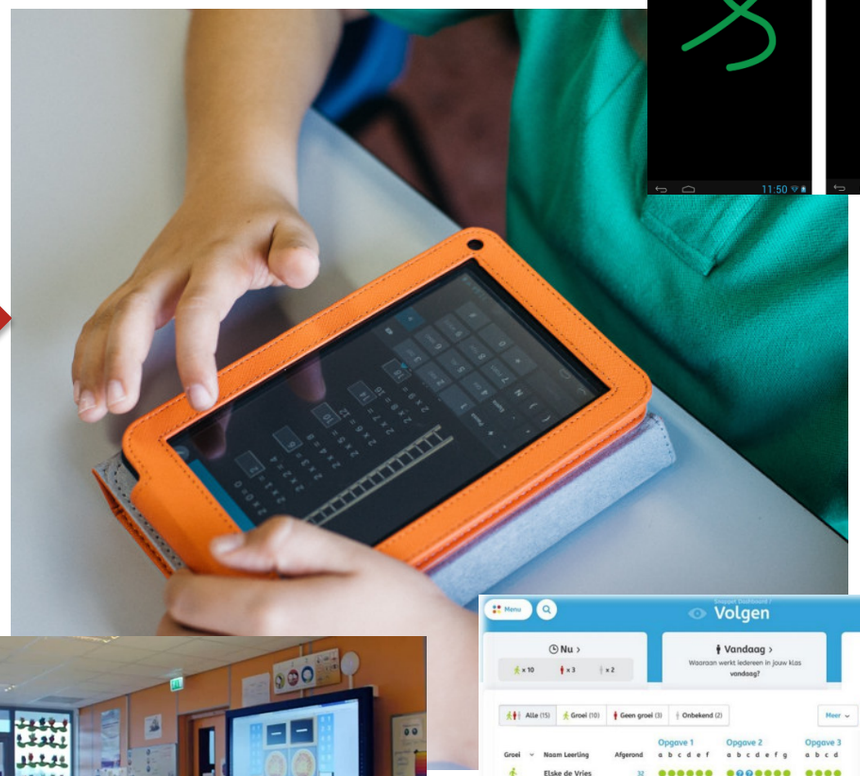


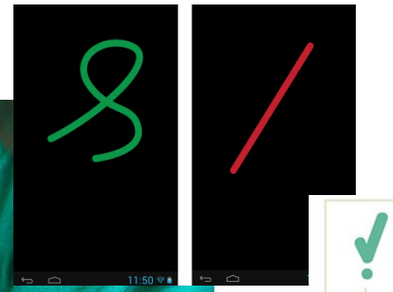
The overall objective is to design, develop and evaluate Hybrid Human-AI Regulation (HHAIR) to support young learners' deep and future learning in the context of ALTs.

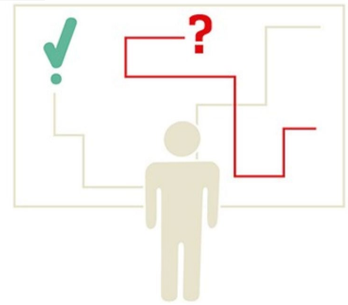
Context: Adaptive Learning Technologies











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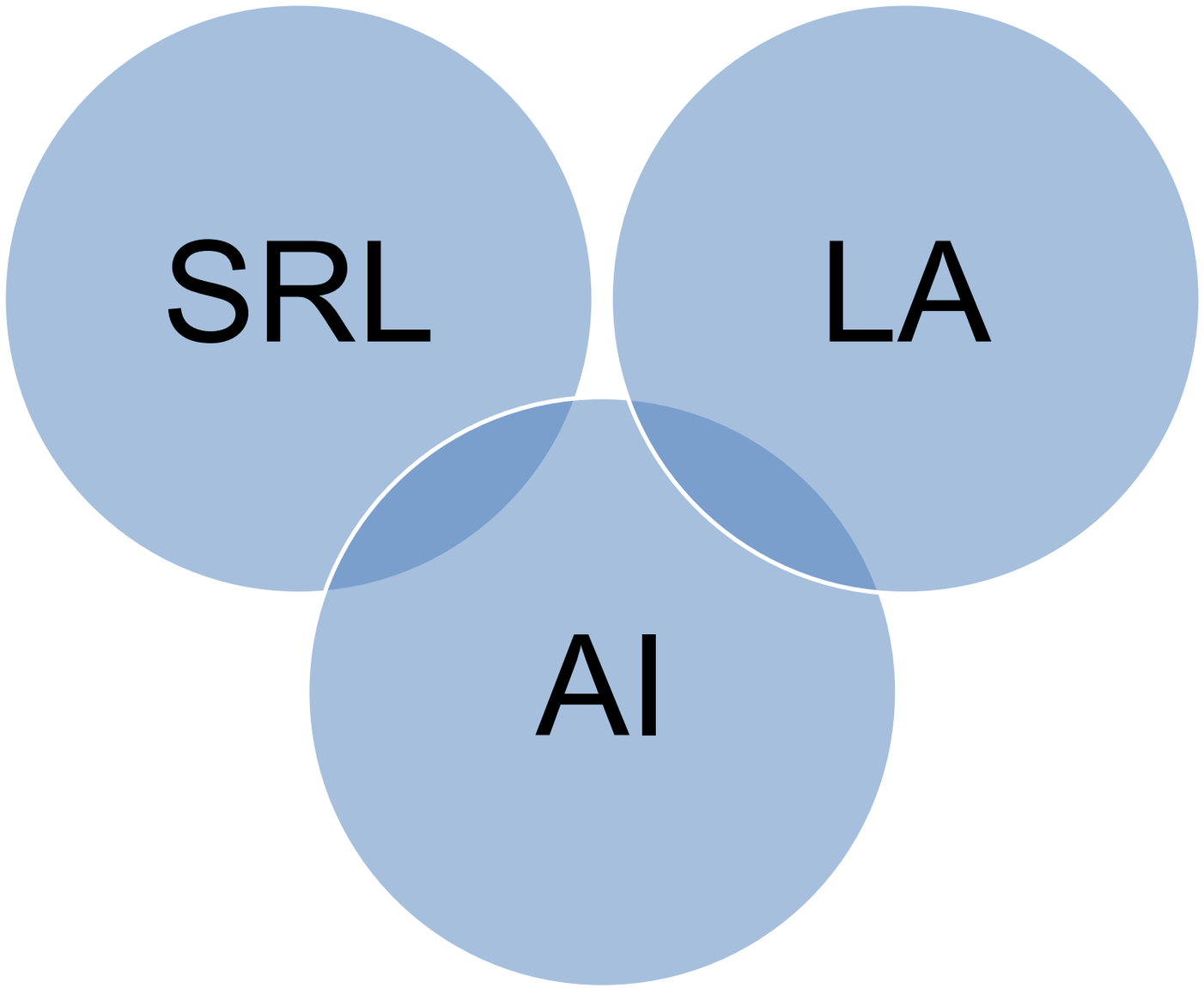
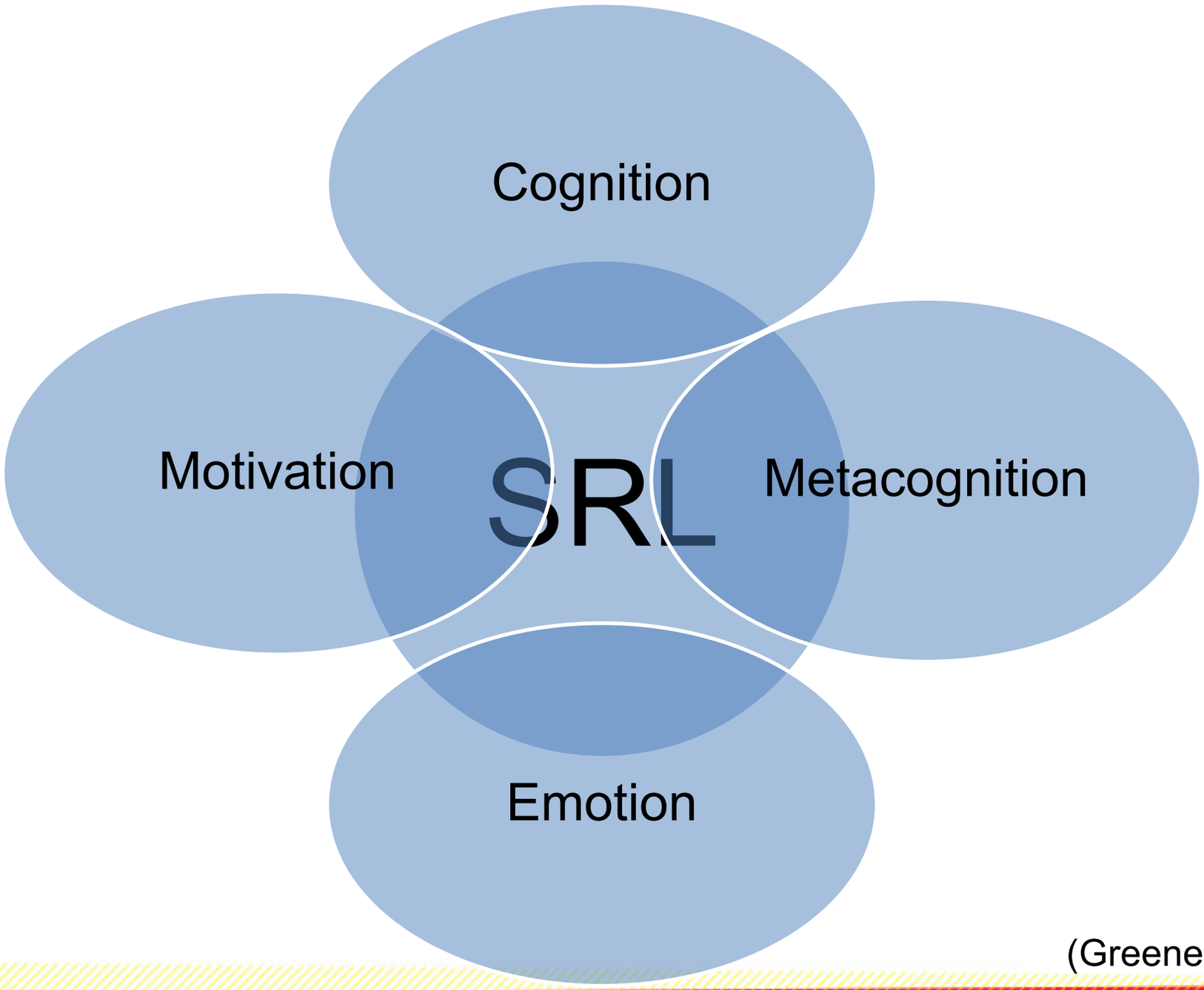
Theoretical Framing

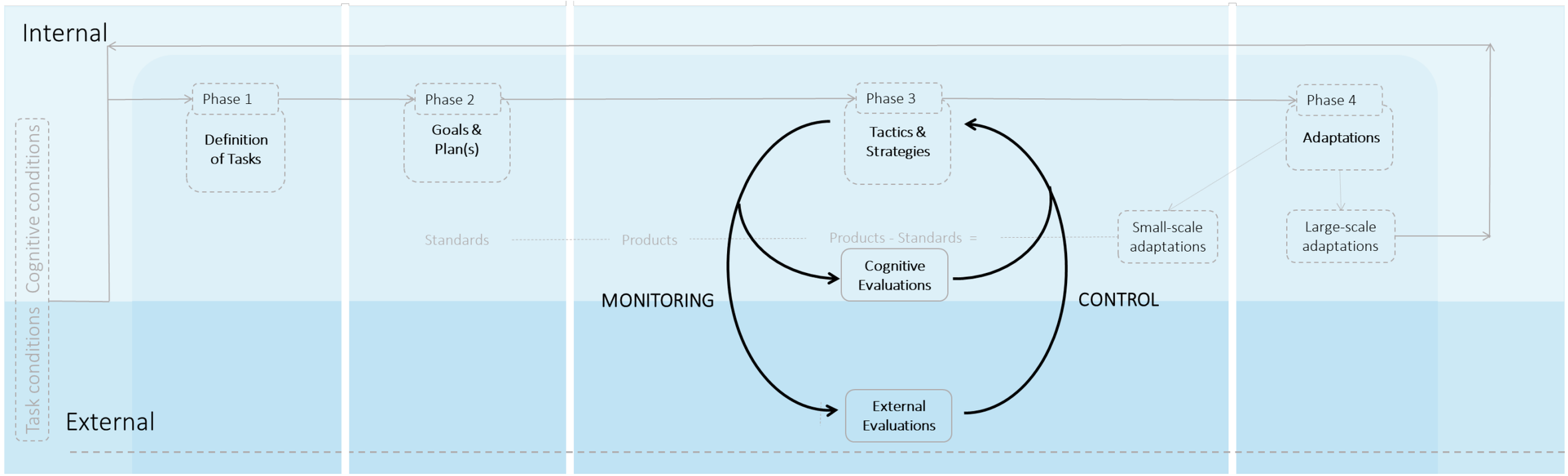


Theoretical Framing: Self-Regulated Learning



(Greene & Azevedo, 2010)

Theoretical Framing:The COPES Model



(Winne & Hadwin, 1998; Panadero et al. 2018)

Theoretical Framing: Learning Analytics

- *extracted analytics,* in the form of learner dashboards to explain to learners how to regulate their learning;

- *embedded analytics,* in the form of advanced algorithms to detect learners' SRL and perform AI-regulation.

- Agency over regulation is gradually transferred from AI to learners, who increasingly becomes more responsible for and active in his/her own regulation.

Challenges

1. Measurement: Identify individual learner's SRL *during* learning

2. Support: Design Hybrid Human-AI Regulation

3. Evaluate effectiveness
   a) optimizing deep learning
   b) for future learning

Measurement of SRL during learning

Traditional measurement SRL

Self-report

Think-aloud

Multimodal Measurements of SRL

Logs

Keyboard & mouse

Physiological data

Eye tracking

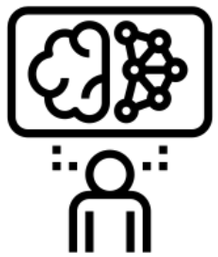
Video

Voice

Measurment of SRL in the context of ALTs

Logs

Knowledge model



Empirical work on Measurement

Moment-by-Moment Learning Curves

- Moment-by-moment learning curves show the probability (*P(J)) a* student learned at each practice opportunity for a specific skill (Baker et al. 2013)

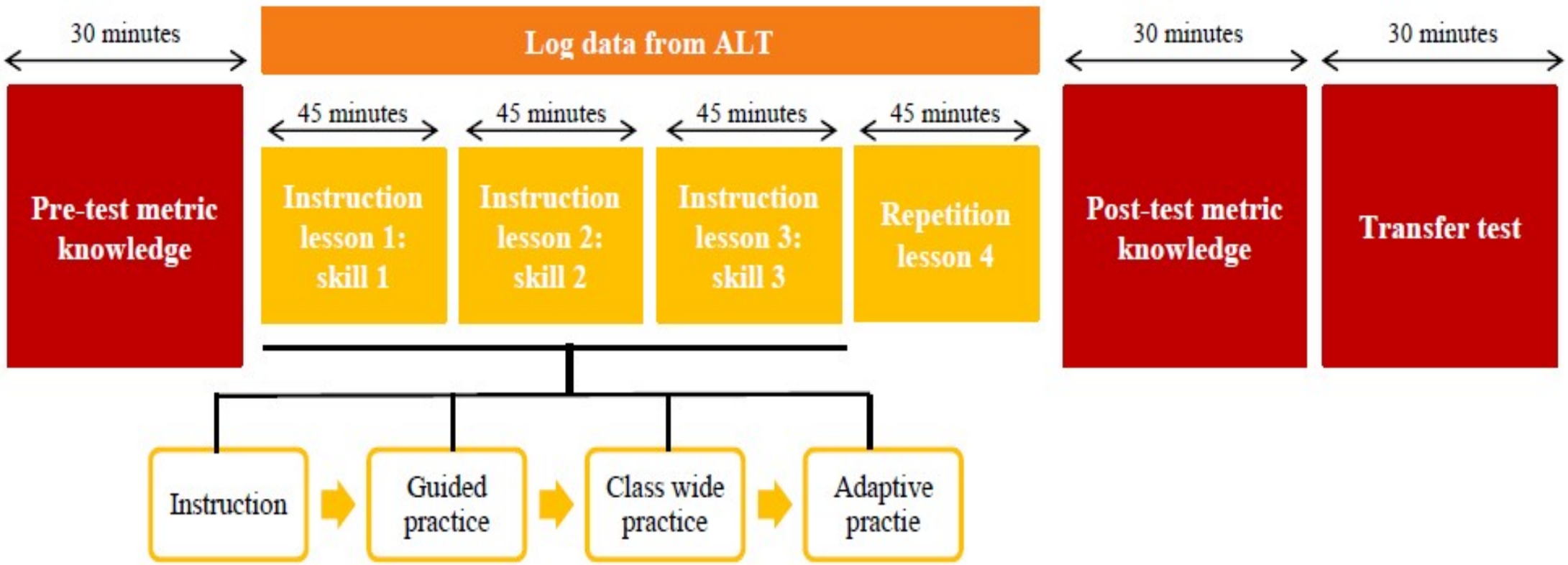
- Indicates gradual vs. sudden learning: spikes show shifts in performance

- Research indicated that spikiness of (*P(J))* is associated with learning (Baker & Goldstein, 2010; 2011)

- 7 Visual patterns were found which were related to different learning outcomes (Baker et al. 2013)
  - immediate peak curves were correlated with retention
  - immediate drop curves were associated with post-test scores

Method

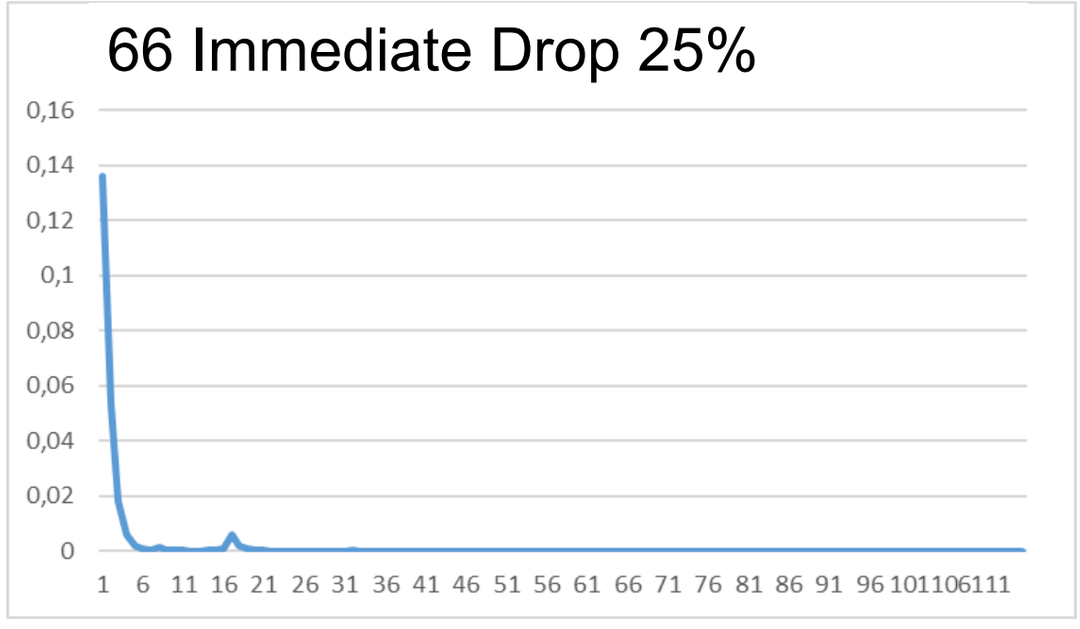
Sample:
- 95 students in grade 5, 4 classes in 4 schools
- 51 boys and 44 girls, average aged 10.88
- 265 curves were used in the analysis
  - curves with less then 15 problem solving attempts were not included

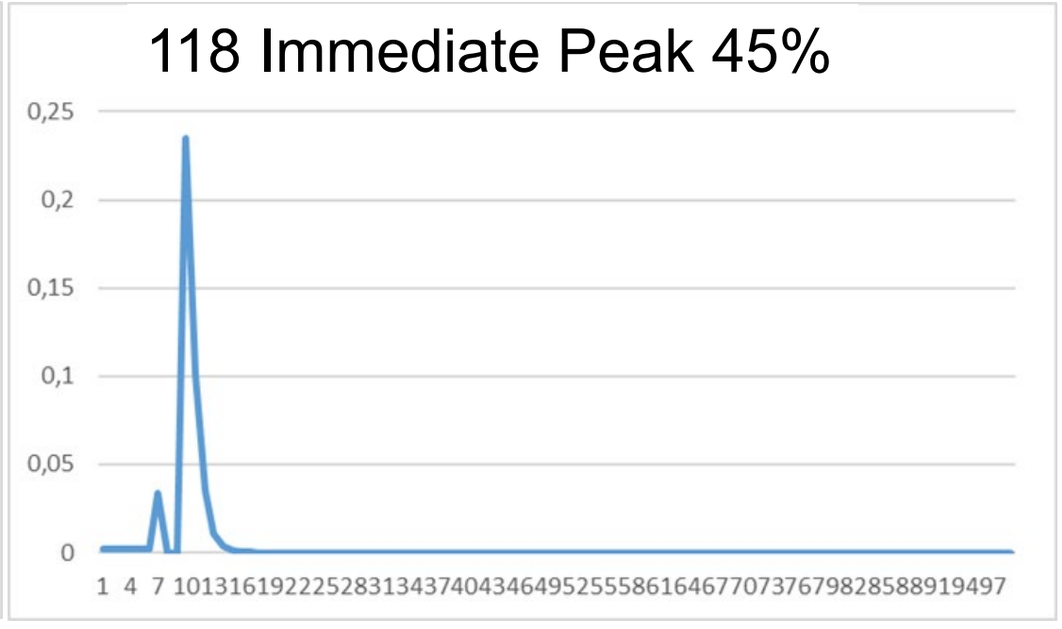


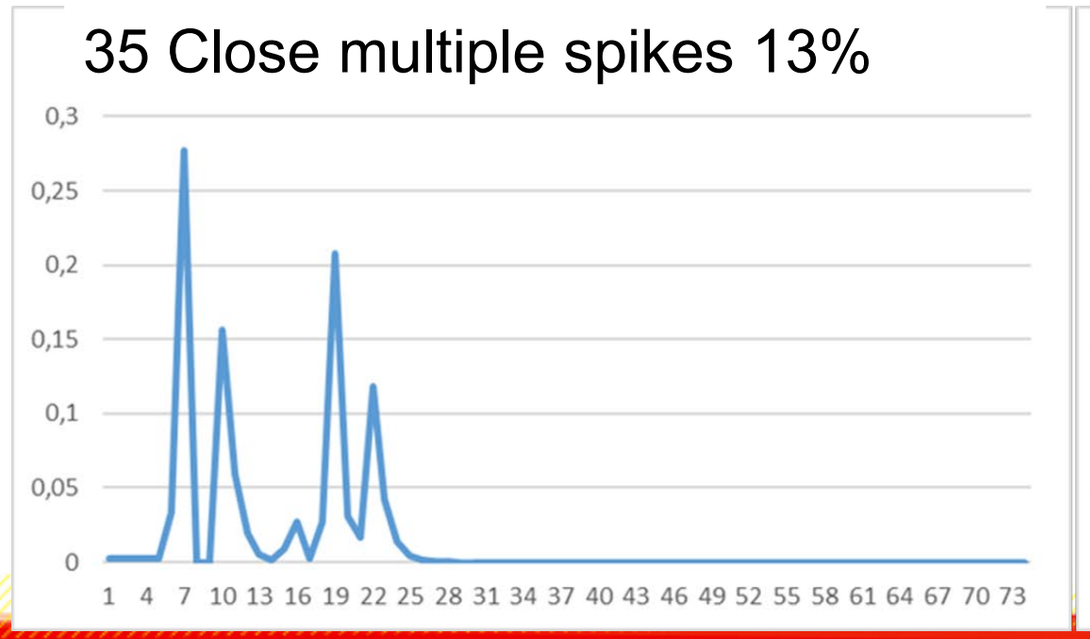
Measurements

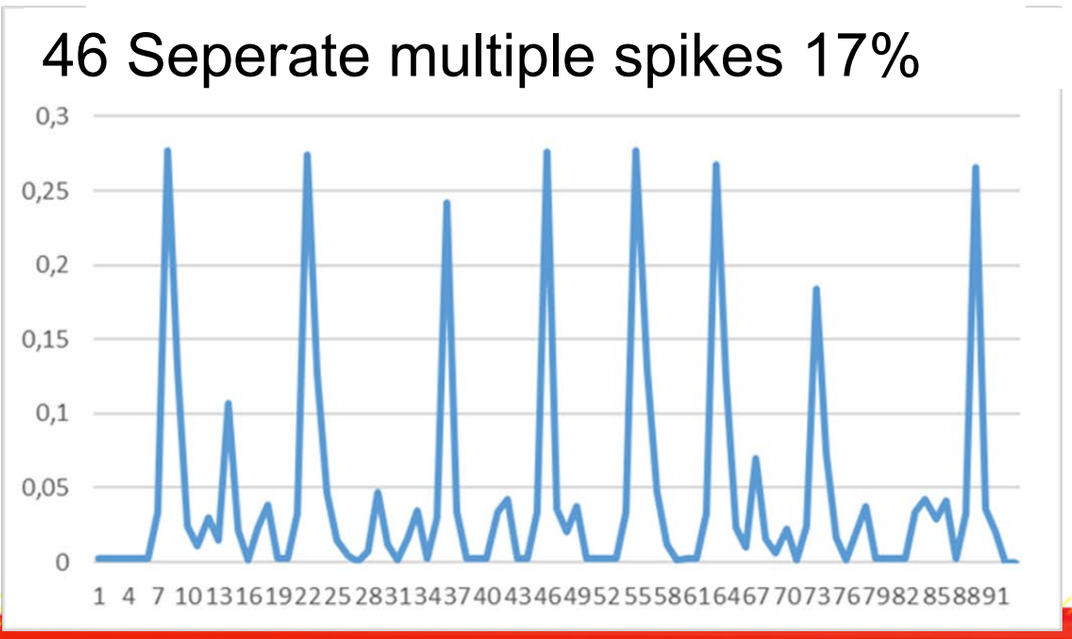
Learning measures	Definition
Prior knowledge	Pre-test, 8 items per subskill
Post Knowledge	Post-test, 8 items subskill
Gain	Post-test - pre-test per subskill
Transfer	15 items test
Process measures	Log file data
Effort	Number of unique problems completed per subskill
Accuracy	Correct unique problems / total unique problems completed

Moments-by-Moments Learning Curves

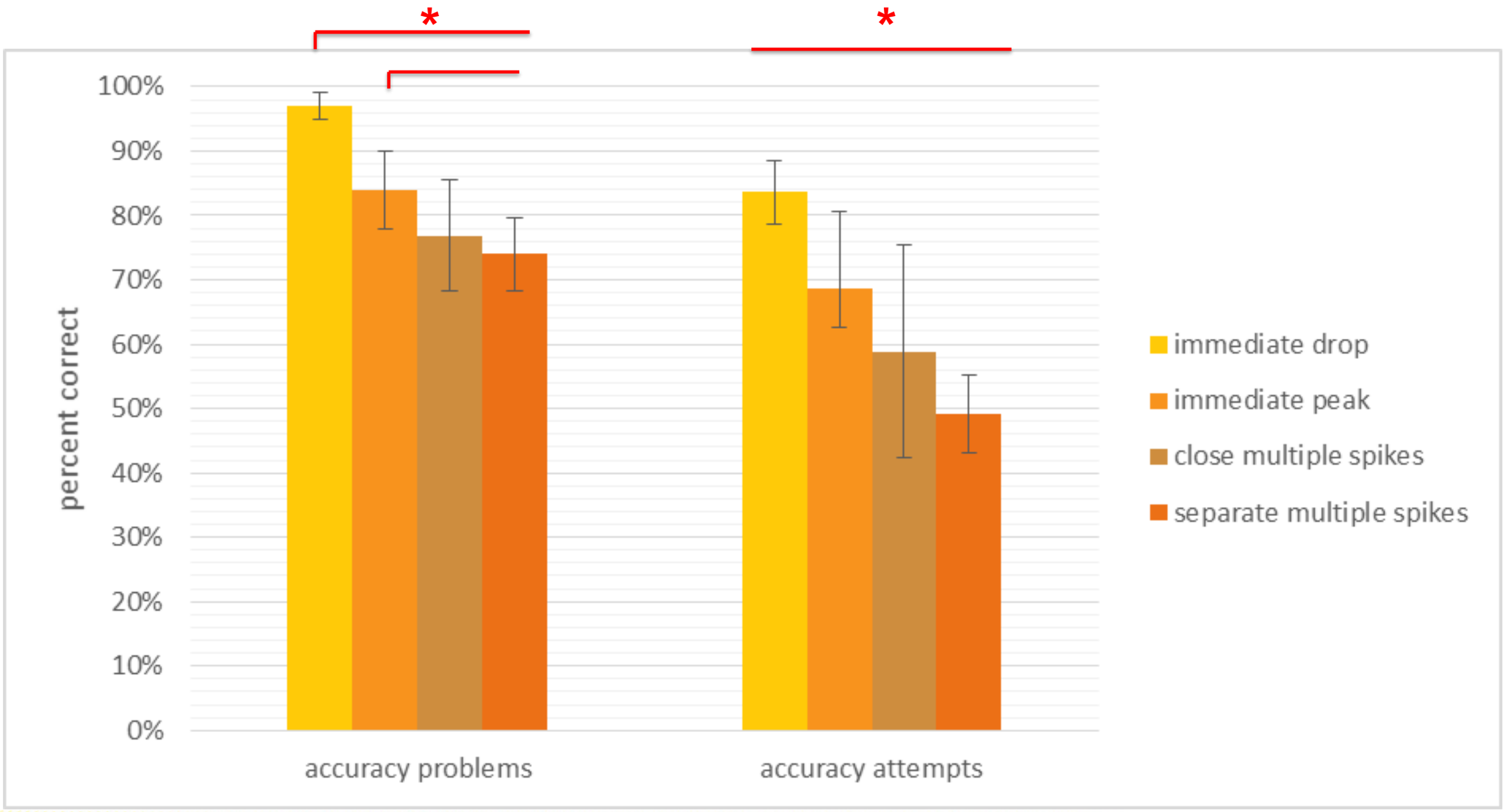








Associations with Accuracy



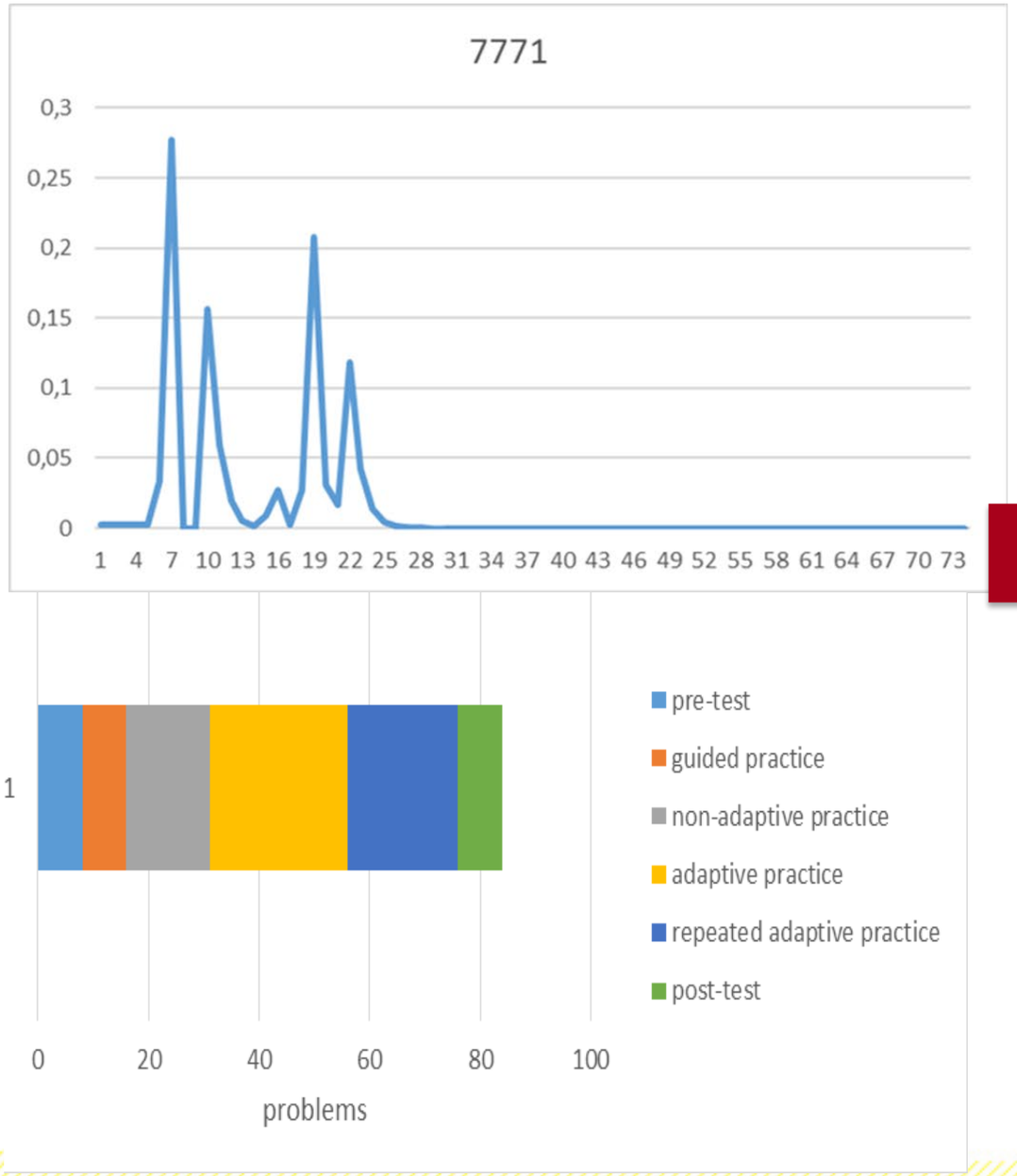
Associations with learning

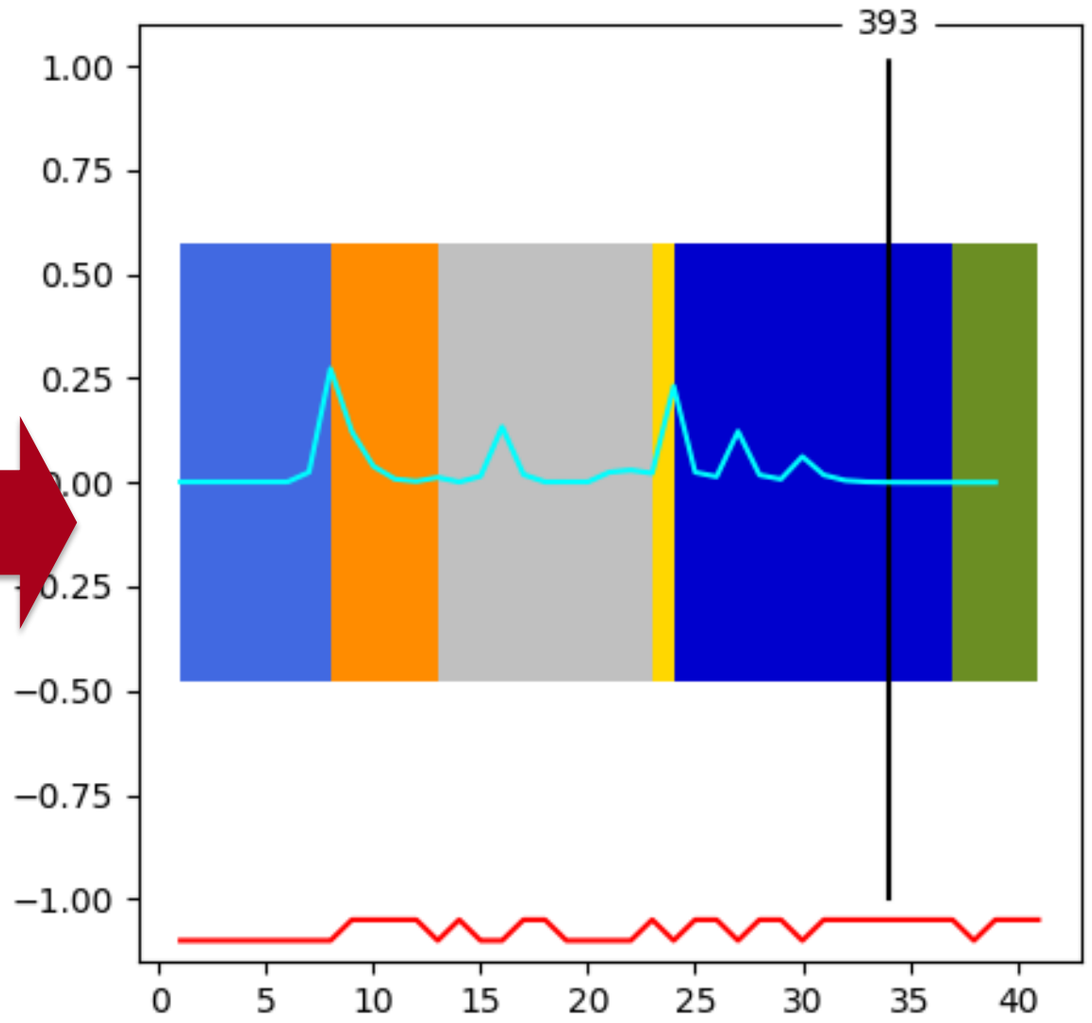
MbML in light of SRL

	Student learning	Student regulation	Human-AI regulation
Immediate drop	Low gain, high transfer	High accuracy	Inefficient learning & regulation
Immediate peak	High gain and transfer	Relatively high accuracy	Efficient learning & regulation
Close separate spikes	Moderate gain and relatively high transfer	Reduced accuracy	Moderate learning & challenges in regulation
Multiple separate spikes	Moderate gain and low transfer	Strongly reduced accuracy	Reduced learning & ineffective regulation

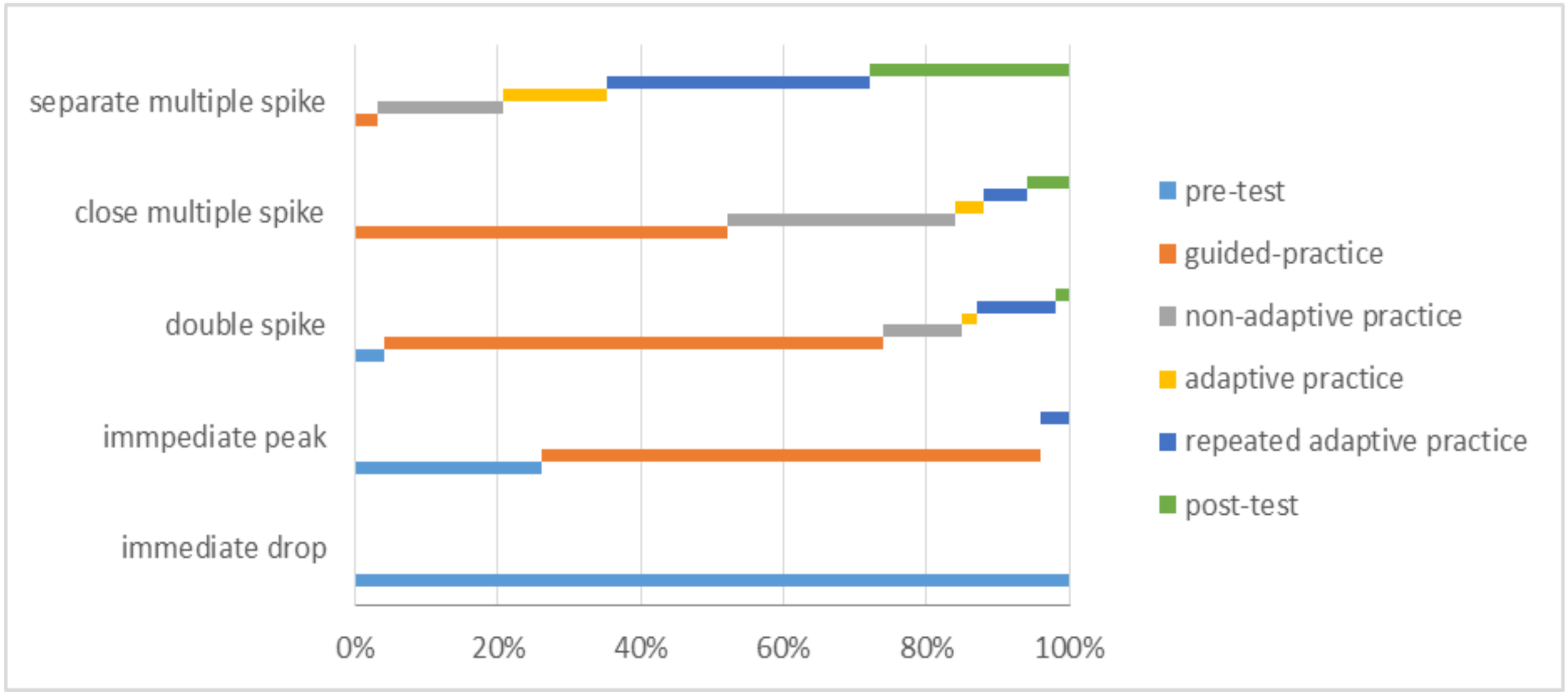
Molenaar, I., Horvers, A. & Baker, R. (2019).

MbMLC & phases in the classroom





MbMLC and peaks in learning phases



Need for SRL support

Groups	MbMLC curves	support
SRL group	Immediate drop	• Reduce teacher and system regulation • Students may benefit from learner-dashboards
	Immediate peak	
Teacher regulation group	Immediate peak	• Continue teacher regulation • Students may benefit from learner-dashboards to improve SRL
	Double Spikes	
	Close multiple spikes	
System regulation group	Close multiple spikes	• Continue teacher and system regulation
Advanced system regulation group	Separate multiple spikes	• Advanced system support

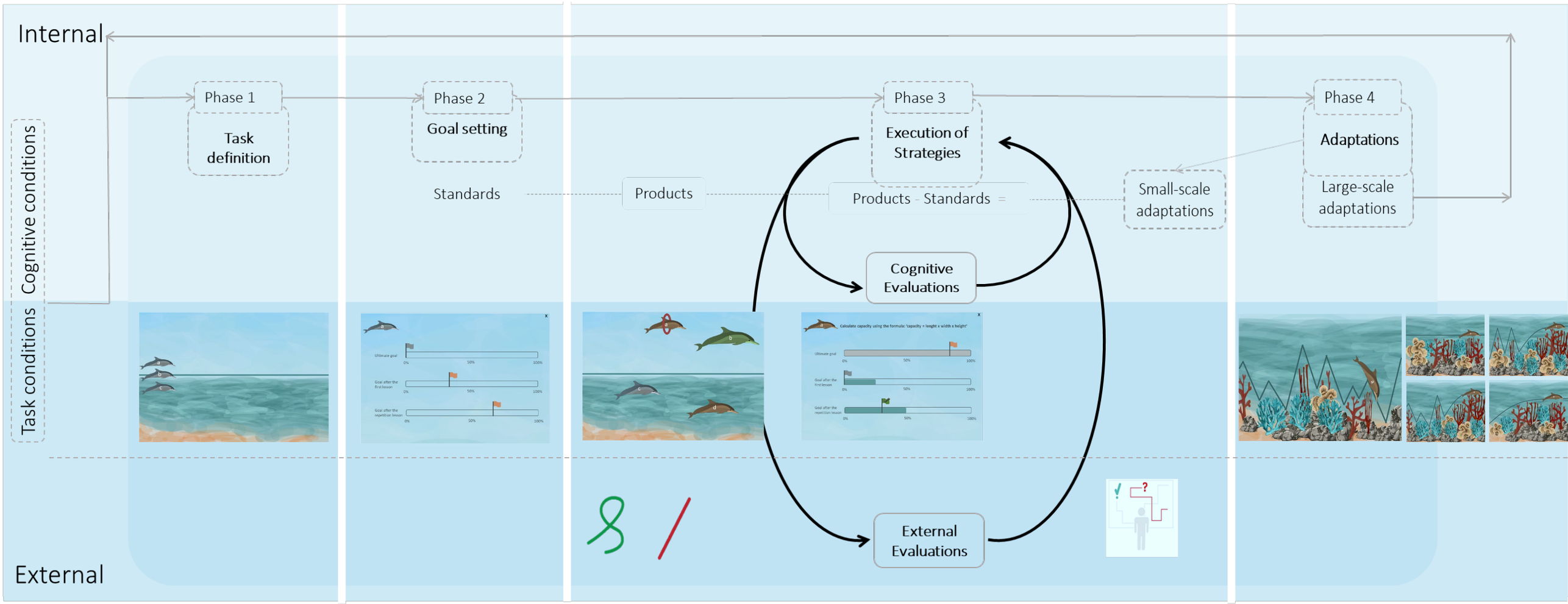
Molenaar, I., Horvers, A. & Baker, R. (2019).

Support: Personalized Dashboards

Designing theory grounded support

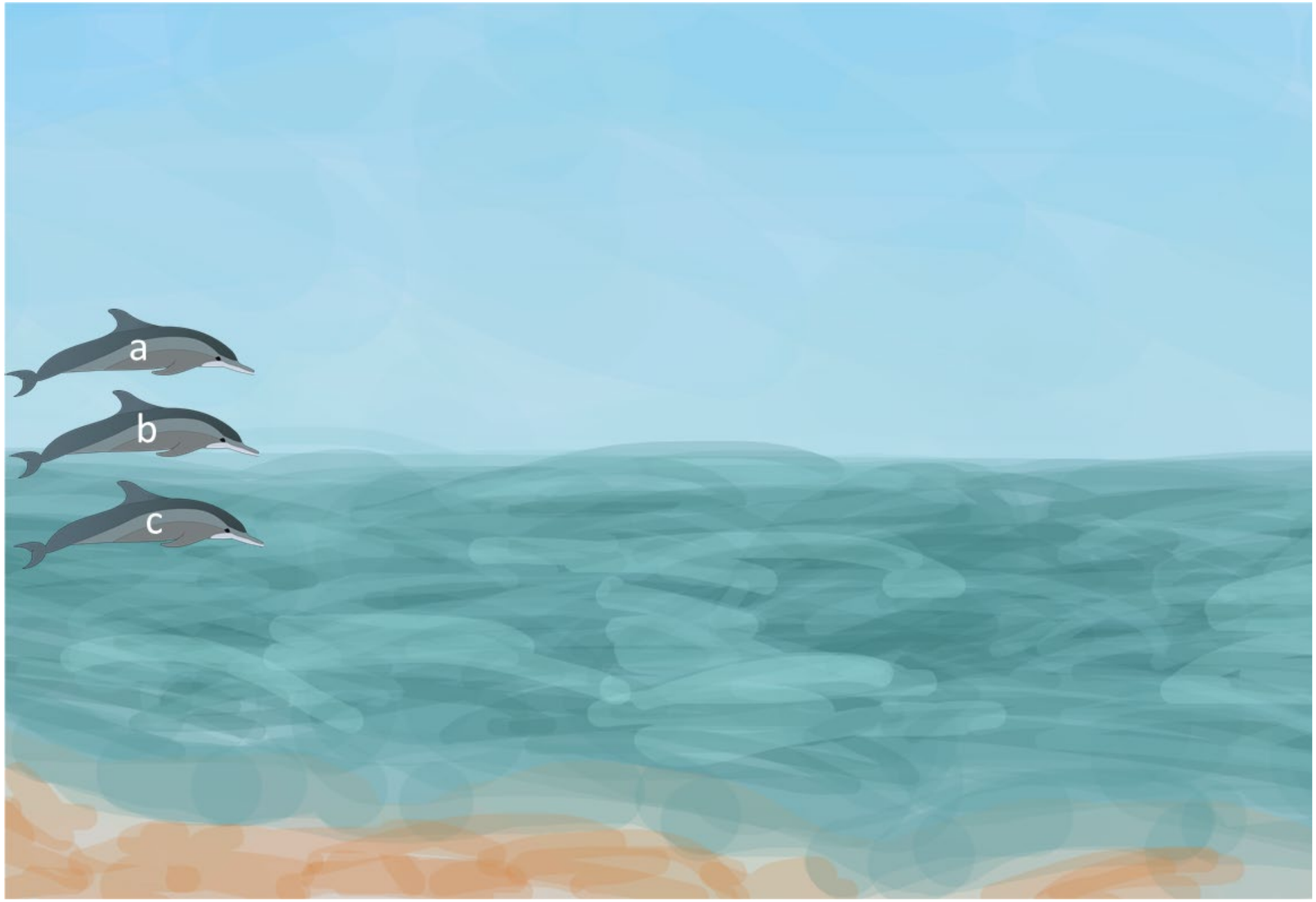
Degrees	AI	Human	Function Dashboard
Self-Regulation	Observes regulation	self-initiation of control	Mirror regulation
Shared-Regulation	Monitors & proposes control	Understands enactment of control	Scaffold enactment of control
Co-Regulation	Monitors & Controls	Understands how AI monitors	Model AI monitoring and control
AI Regulation	Monitors & Controls	Aware of AI regulation	Raise awareness

The design of the Learning Path App

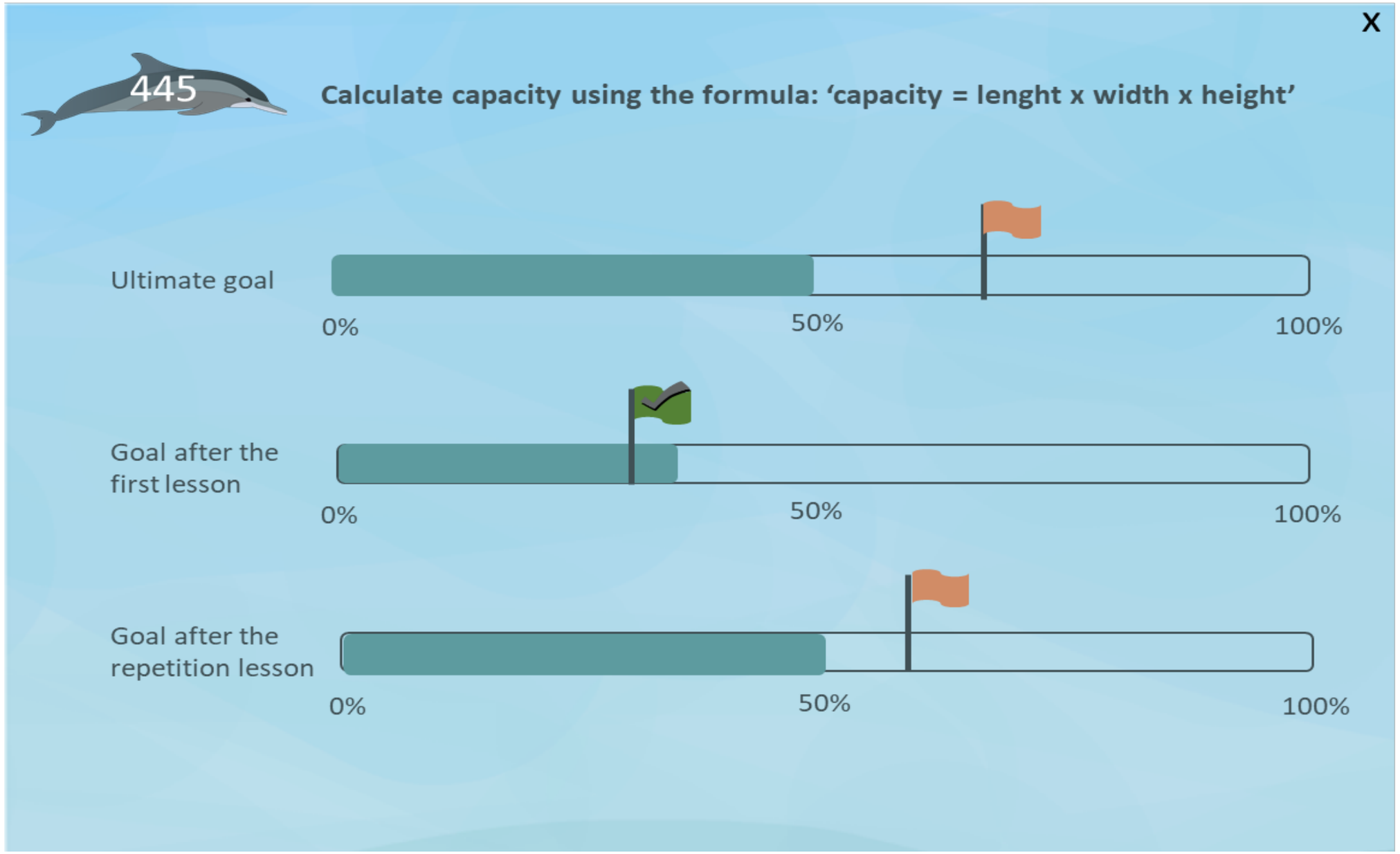


Winne & Hadwin, 1998;2013)

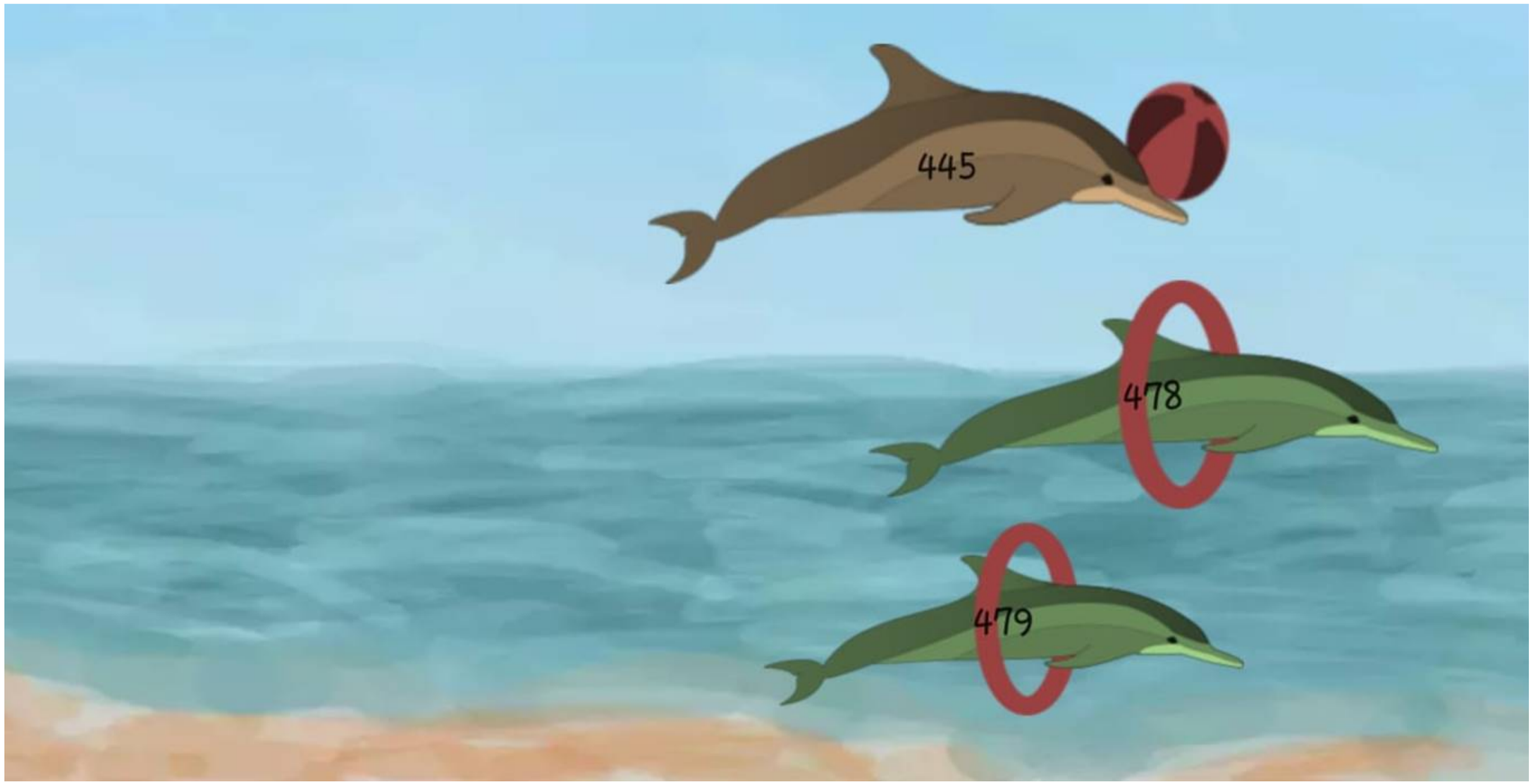
Task Definition Phase: Overview Screen



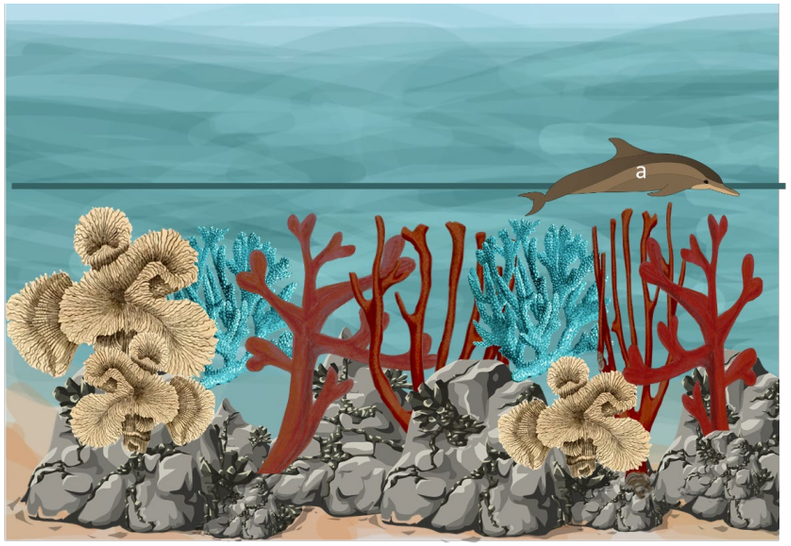
Goal Setting Phase: Goal Setting Screen

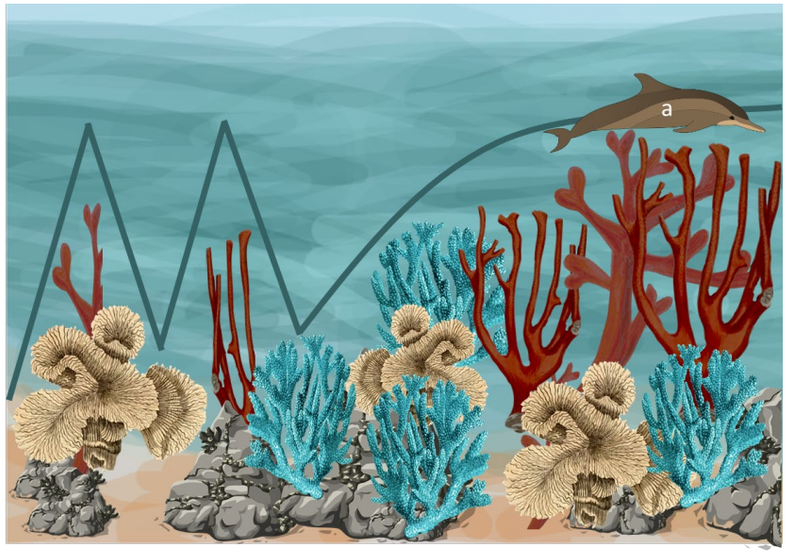


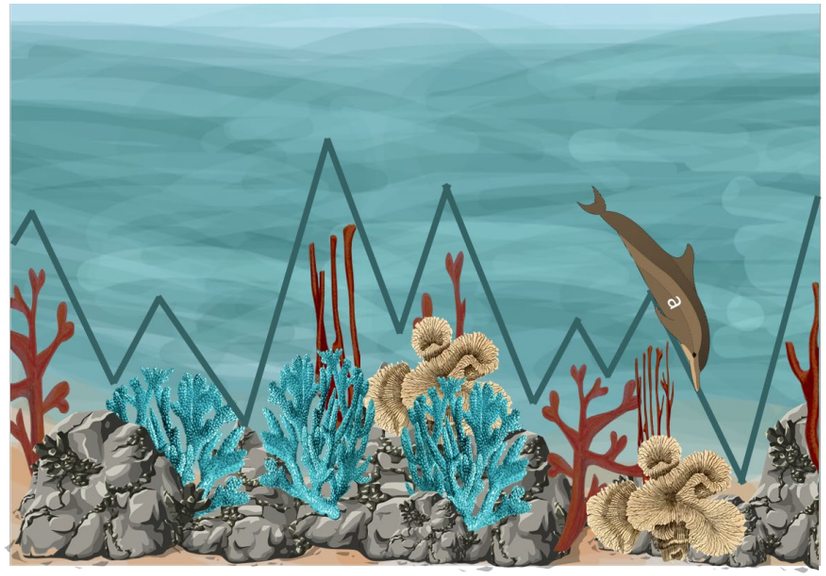
Enactment Phase: Overview Screen

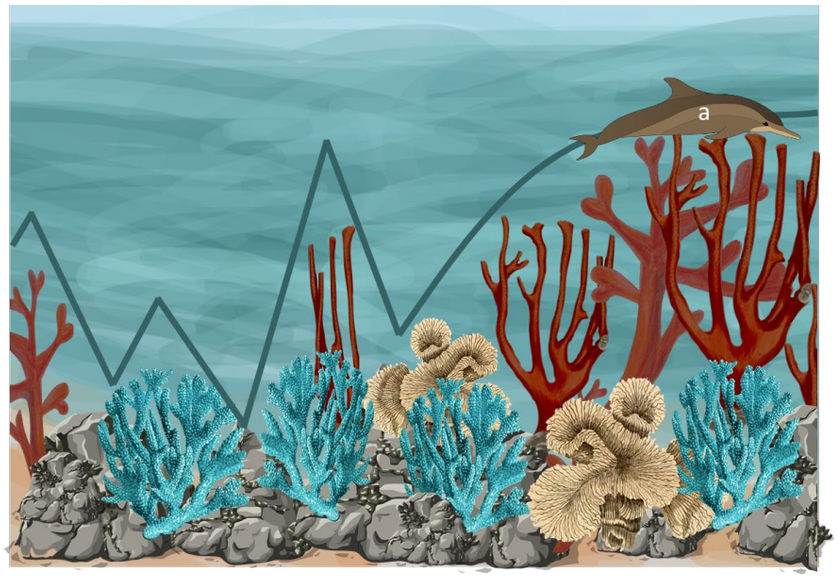


Adaptation Phase: Learning Path Screen









(Molenaar, Horvers & Baker, 2020

In the classroom

Posters

Leerpaden app

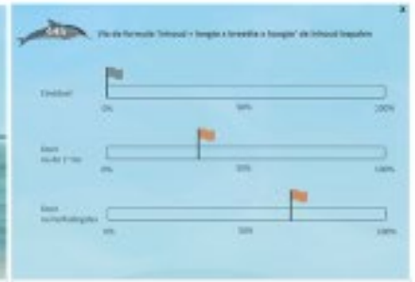
Eerste les

Overzichtsscherm

- De nummers in de dolfijn zijn de leerdoelen.

Kleur van de dolfijn:
- Grijs: je hebt nog geen doel gesteld.

→ Klik op de dolfijn om je doel te stellen.

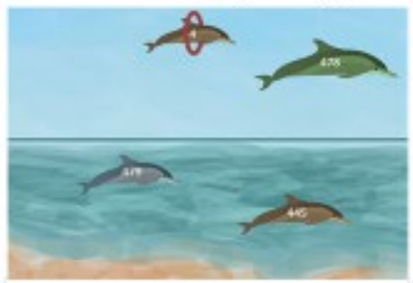


Doel zetten scherm

Stel je doelen:
- Einddoel: hoe ver denk je dat je kunt komen op dit leerdoel?
- Doel na 1e les: hoe ver denk je te komen na de 1e les?

Kleur van de vlaggetjes:
- Grijs: je hebt nog geen doel gesteld.
- Oranje: je hebt een doel gesteld, maar het nog niet behaald.

Verder werken met Leerpaden app



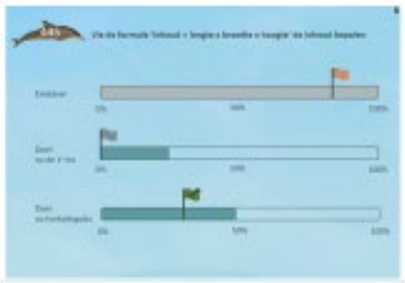
Overzichtsscherm

Grootte van de dolfijn:
- Klein: je hebt nog weinig geoefend op dit leerdoel.
- Groot: je hebt al veel geoefend op dit leerdoel.

Plek van de dolfijn:
- Rechts: je moet nog meer oefenen op dit leerdoel.
- Links: je bent goed bezig op dit leerdoel.

Kleur van de dolfijn:
- Groen: je hebt je doel behaald.
- Oranje: je hebt je doel nog niet behaald.
- Grijs: je hebt nog geen doel gesteld → klik op de dolfijn om een doel te stellen.

- Hoepel: je hebt je doel voor na de 1e les behaald. Bel: je hebt je doel voor na de herhalingsles behaald.



Doel zetten scherm

Stel je doelen:
- Doel na herhalingsles: hoe ver denk je te komen in de herhalingsles?

Kleur in de balkjes:
- Grijs: je score is nog niet bekend.
- Donkere kleur: hoe ver je bent gekomen.

Kleur van de vlaggetjes:
- Groen en vinkje: je hebt het doel behaald.

Leerpaden app

Hoog zwemmer

Je kent het leerdoel al.
Je werkt nauwkeurig, heel goed!

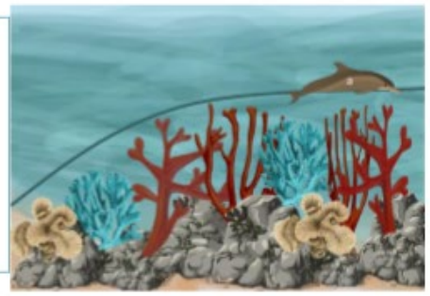
- Kies een ander leerdoel om mee te oefenen.

Snelle stijger

Je hebt snel geleerd.
Je werkt nauwkeurig, heel goed!

Is je dolfijn groen?
- Kies een ander leerdoel om mee te oefenen.

Is je dolfijn oranje?
- Oefen verder tot de dolfijn groen wordt
  OF
- Kies een ander leerdoel om mee te oefenen.



Langzame stijger

Je hebt geleerd na de uitleg van je juf of meester.
- Zorg dat je nauwkeurig werkt.

Is je dolfijn groen?
- Kies een ander leerdoel om mee te oefenen.

Is je dolfijn oranje?
- Oefen verder tot de dolfijn groen wordt
  OF
- Kies een ander leerdoel om mee te oefenen

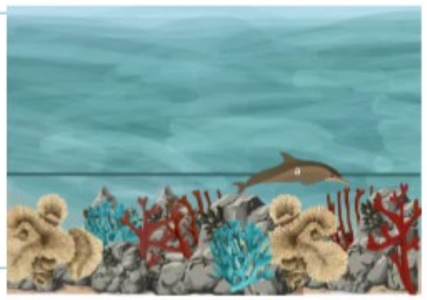
→ Probeer een snelle stijger te worden!

Laag zwemmer

Je bent langzaam aan het leren.

- Stel vragen aan je juf of meester als je het niet snapt.
- Zorg dat je nauwkeurig werkt.
- Oefen totdat de dolfijn groen wordt.

→ Probeer een langzame stijger te worden!



Stijger en daler

Je bent langzaam aan het leren.

- Stel vragen aan je juf of meester als je het niet snapt.
- Zorg dat je nauwkeurig werkt.
- Oefen totdat de dolfijn groen wordt.

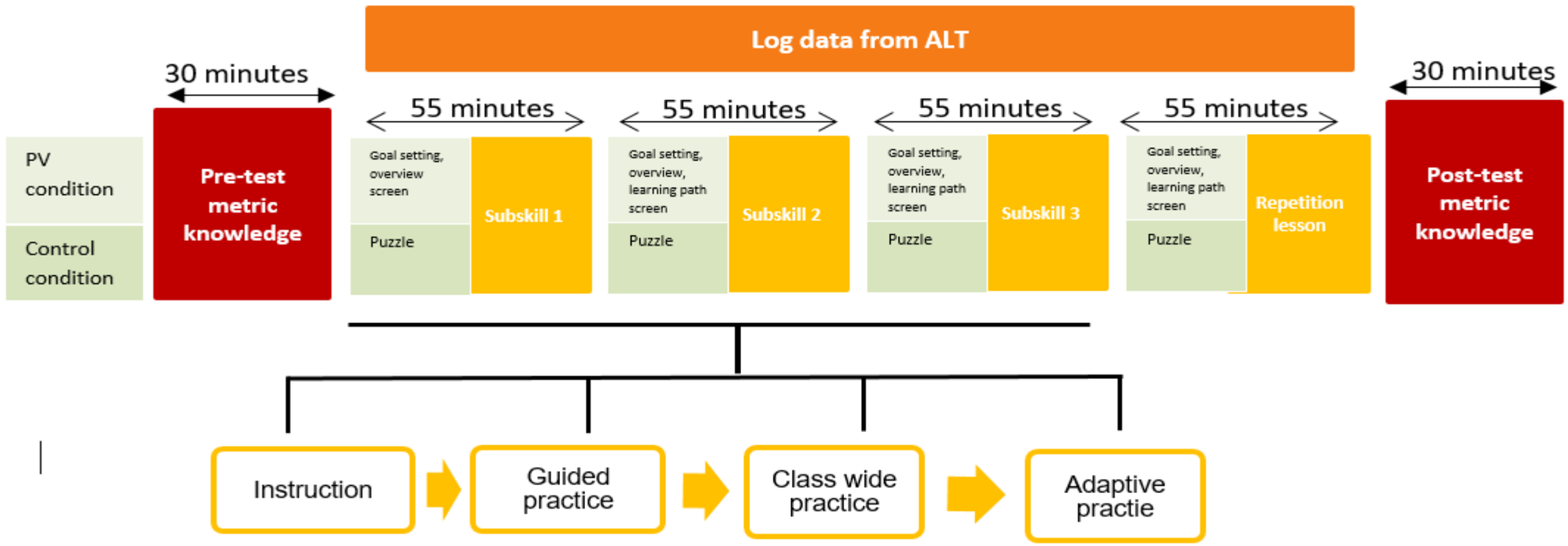
→ Probeer een langzame stijger te worden!

Empirical work on Support

Design

Sample:

- 92 students in grade 5, 5 classes in 4 schools
- Experimental condition n=60 and control condition n=32
- Learners average ages 10.15 between 10 and 12 years old
- 38 boys and 54 girls

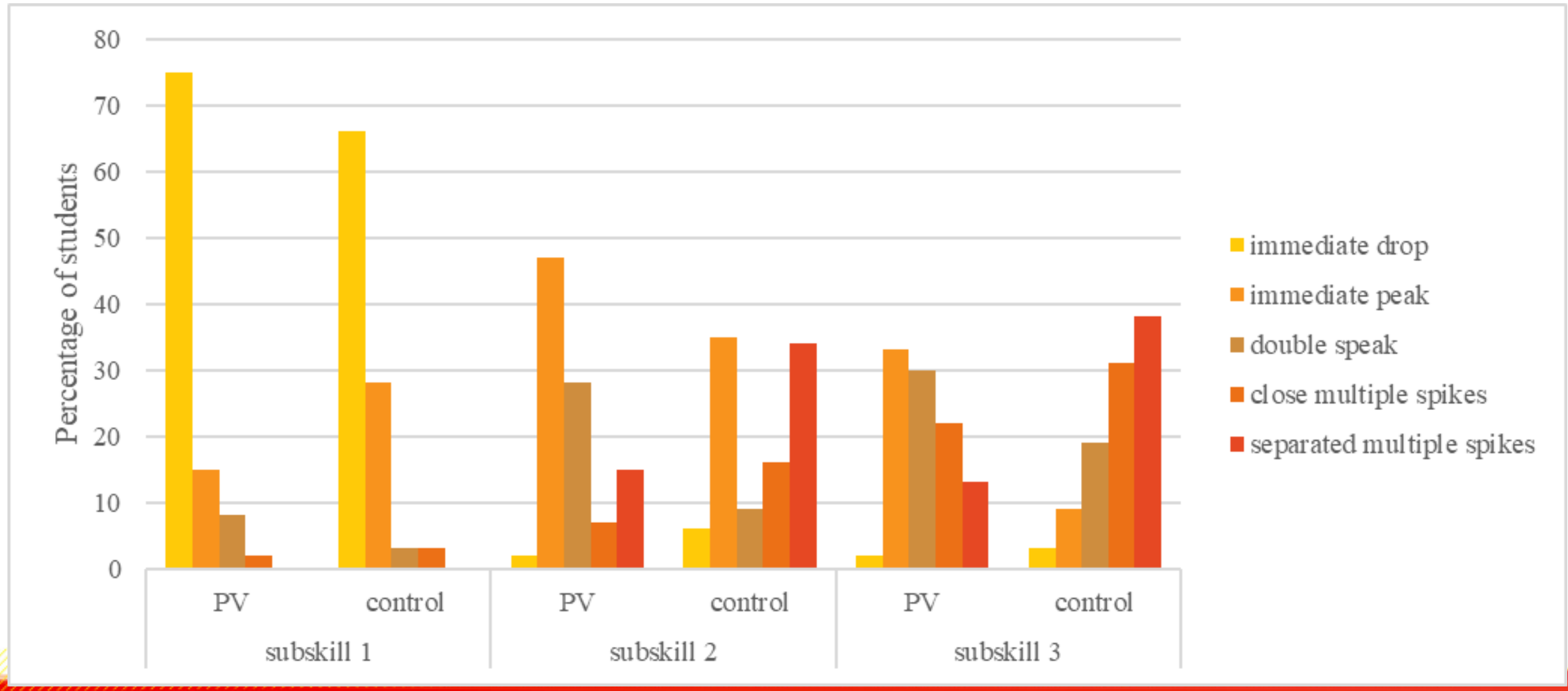


Measurements

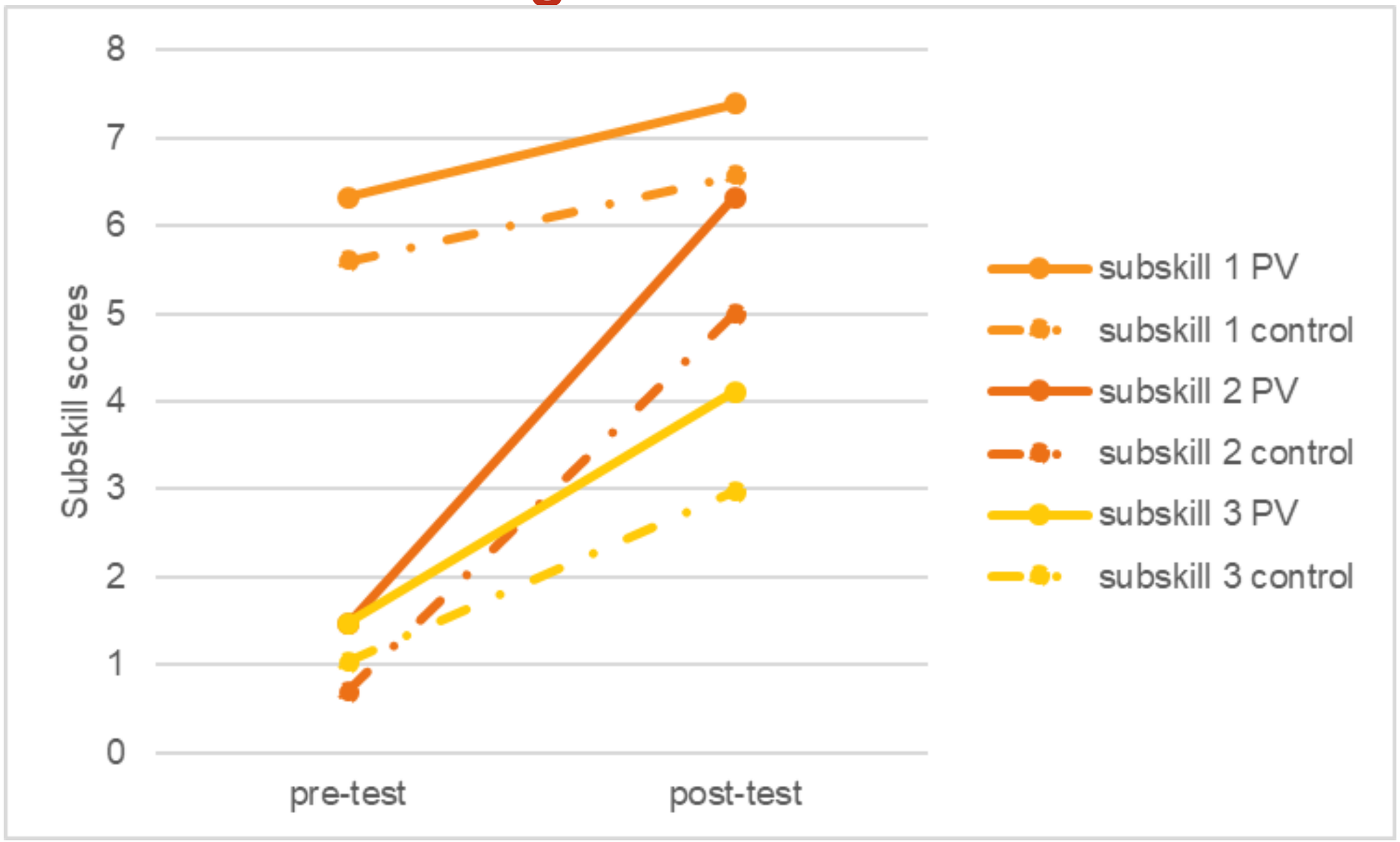
Learning measures	Definition
Prior knowledge	Pre-test, 8 items per subskill
Post Knowledge	Post-test, 8 items subskill
Gain	Post-test - pre-test per subskill
Transfer	15 items test
Process measures	Log file data
Effort	Number of unique problems completed per subskill
Accuracy	Correct unique problems / total unique problems completed

Effects of Regulation of Practice Behavior

- Significant effect on accuracy $F(2, 85) = 4.88$, $p < 0.01$
- No effect of effort, $F(2, 85) = 1.62$, $p > 0.05$
- Improved practice behavior for skill 2 and 3

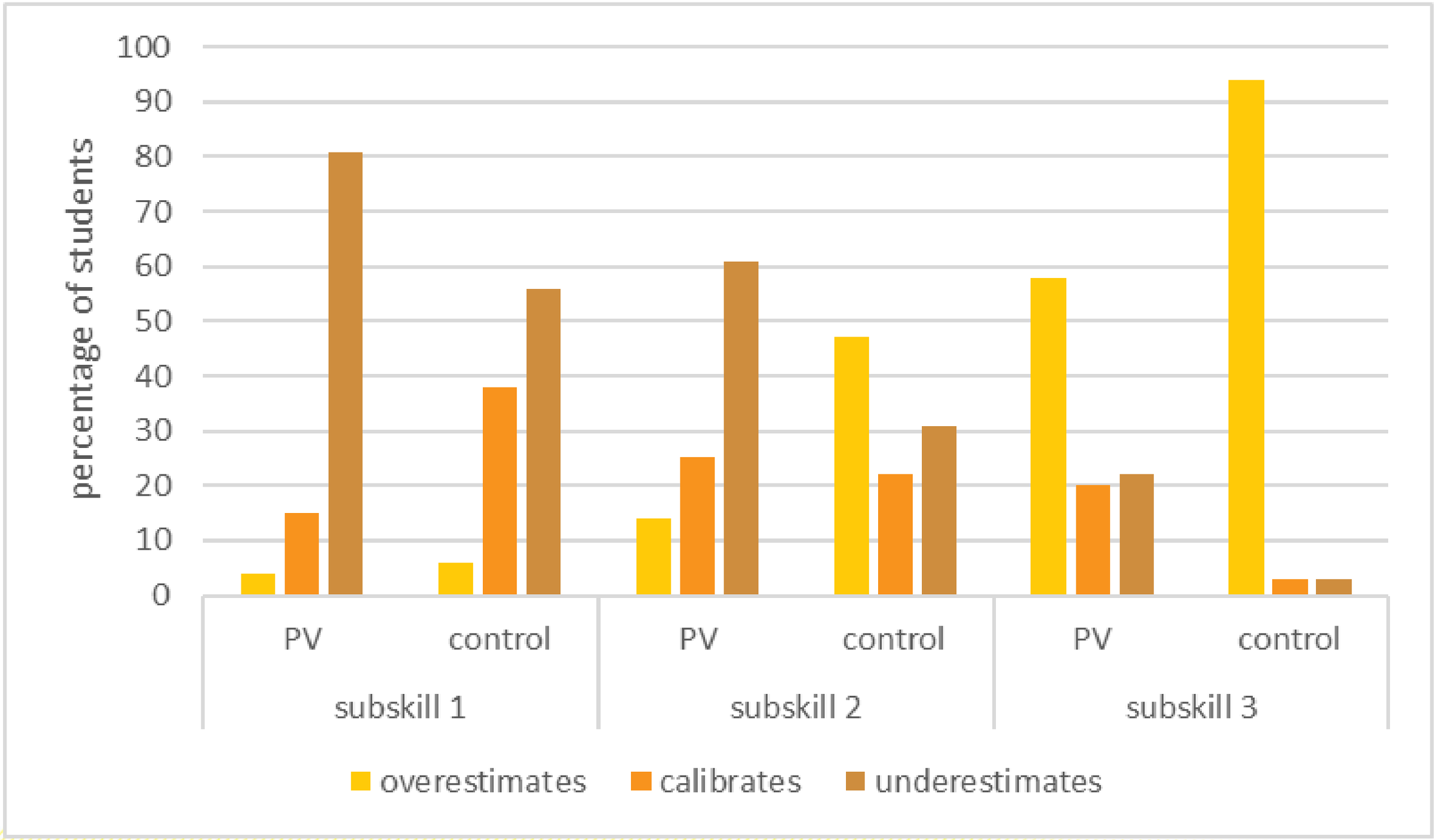


Effects on learning outcomes



Significant effect on transfer $t(85, 2) = 2.33$, $p < 0.05$

Effects on Monitoring Accuracy



Towards Hybrid Human-AI Regulation

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Designing theory grounded support

Degrees	AI	Human	Function Dashboard
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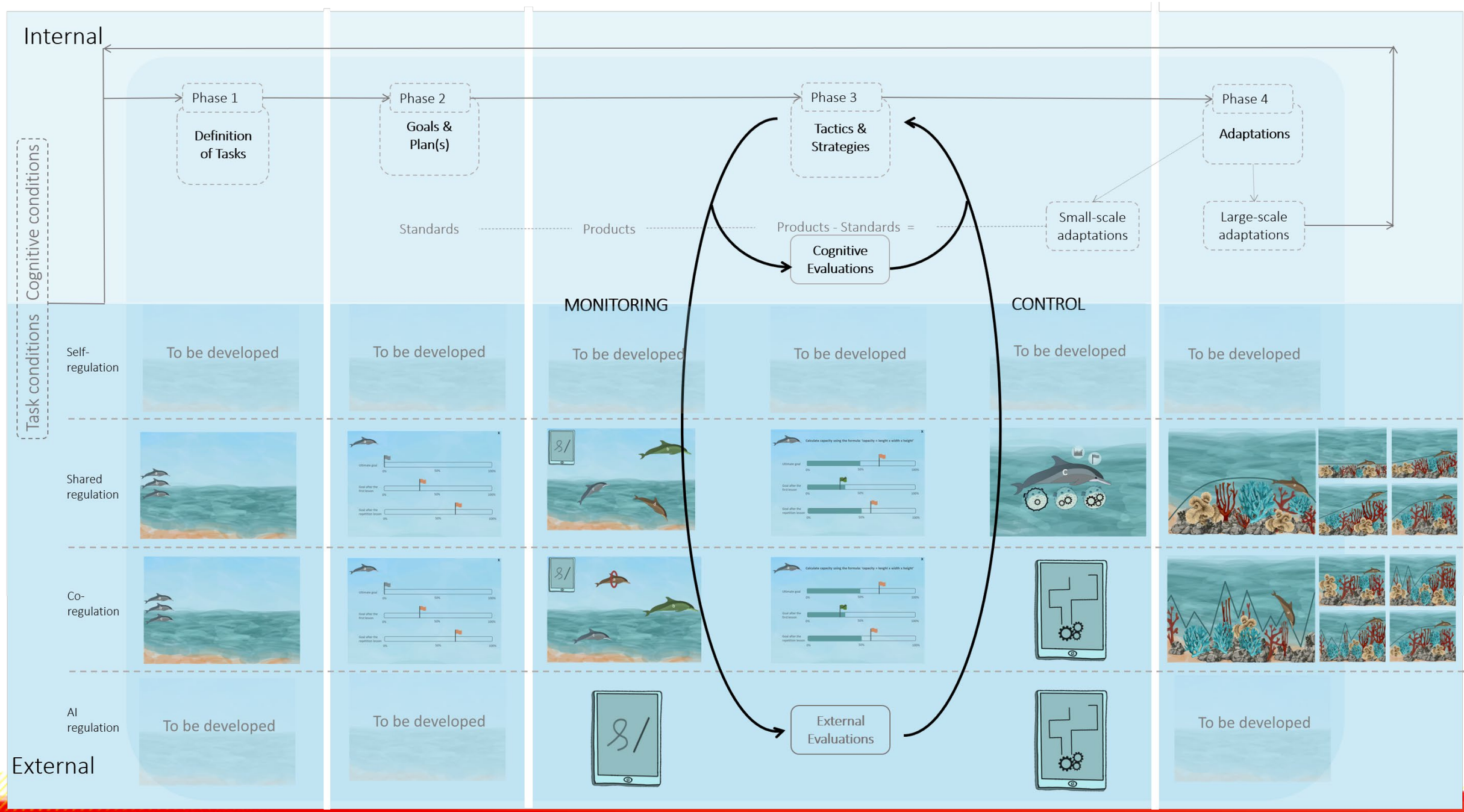
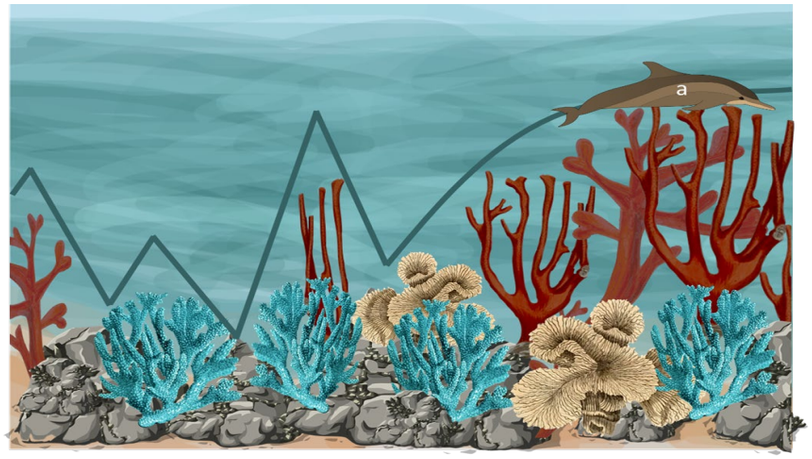
Hybrid Human-AI Regualtion



Hybrid Human-AI Regulation: Transfer of Control



Would you like to read more?

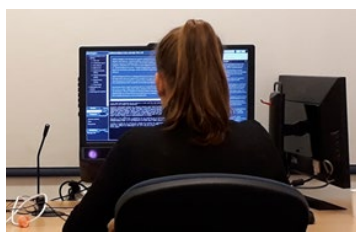
Molenaar, I., Horvers, A. & Baker, R. (2019). What can Moment-by-Moment learning Curves Tell about Students' Self-Regulated Learning? Learning and Instruction.

Molenaar, I., Horvers, A. & Baker, R. (2019). Towards Hybrid Human-System Regulation: Understanding Children' SRL Support Needs in Blended Classrooms. *In proceedings of the 9th International Conference on Learning Analytics & Knowledge,* pp. 471- 480, ACM

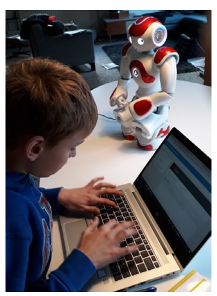
Molenaar, I., Horvers, A. & Dijkstra, R. (2019). Young Learners' Regulation of Practice Behaviour in Adaptive Learning Technologies. *Frontiers in Psychology: Educational Psychology*, 10, 2792

Molenaar, I., Horvers, A. Dijkstra, R. & Baker, R. (2020). Personalized Visualizations to Promote Young Learners' SRL: The Learning Path App. *In proceedings of the 10th International Conference on Learning Analytics & Knowledge,* ACM

Dr. Inge Molenaar
Adaptive Learning Lab





FLORA

moodle

Read?

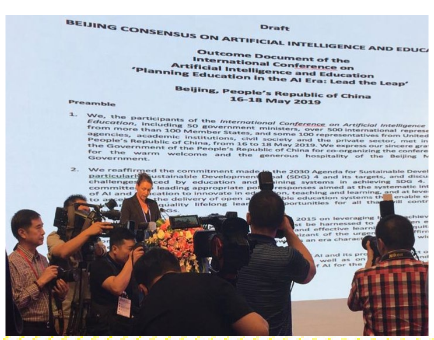
Leerpaden app

Gynzy

snappet Connected Learning

ThiemeMeulenhoff

zwijsen Breng leren tot leven



UNESCO

BEIJING CONSENSUS

stichting Klasse

Lucas Onderwijs

Want to work with us?

- We are looking for
  - A Post-Doc with a strong AI background
  - A Post-Doc combining educational insights with LA and AI

- This Spring:
  - PhD for designing teacher Dashboards
  - PhD for measuring and supporting SRL in Secondary Education

Thank you for your attention

Inge.Molenaar@ru.nl

Behavioural Science Institute

Adaptive Learning Lab
- ALL -

Radboud University