Dr Wayne Holmes

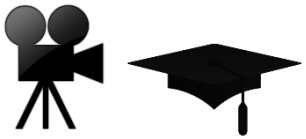
Institute of Educational Technology, The Open University

Talking, feedback, inhibition, emotions... and learning.

Beijing Normal University (BNU)
Beijing, 21 April 2017

ABOUT ME

The Open University



BA Film, MA Philosophy

~8 years teaching (film, photography and media studies)

~8 years making educational films

CatchUp®

~8 years as Head of Research for an international children's educational charity (developing and researching interventions)

UNIVERSITY OF OXFORD

MSc Education, PhD Education (Learning and Technology)
University of Oxford

PhD THESIS PROJECT

UNIVERSITY OF OXFORD

'Level Up! A Design-based Investigation of a Prototype Digital Game for Children who are Low-attaining in Mathematics.'

Methodology: Design-based research grounded in the learning sciences.

Design-Based Research Collective (2003). 'Design-Based Research: An Emerging Paradigm for Educational Inquiry', *Educational Researcher*, vol. 32, no. 1, pp. 5–8.

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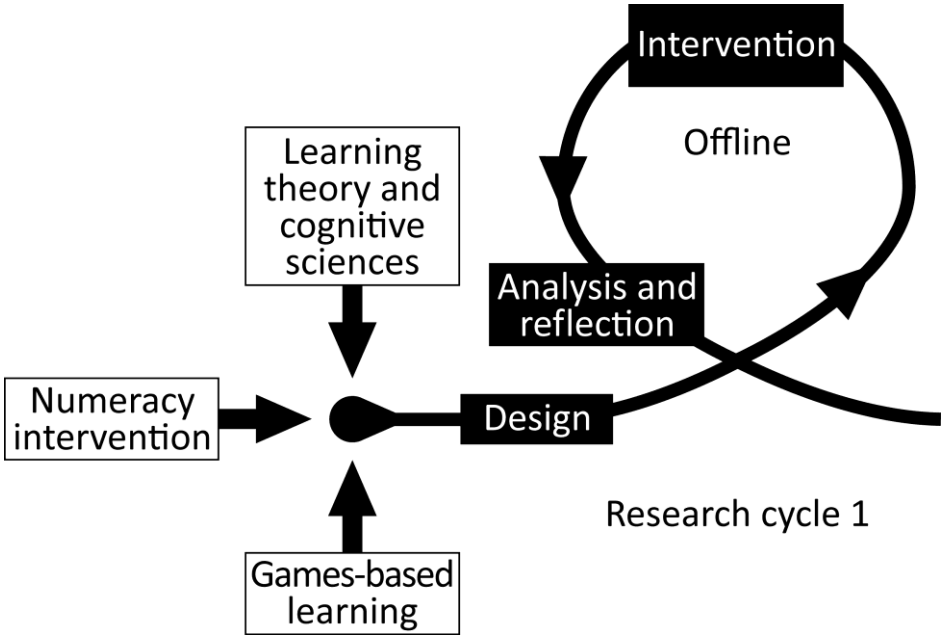

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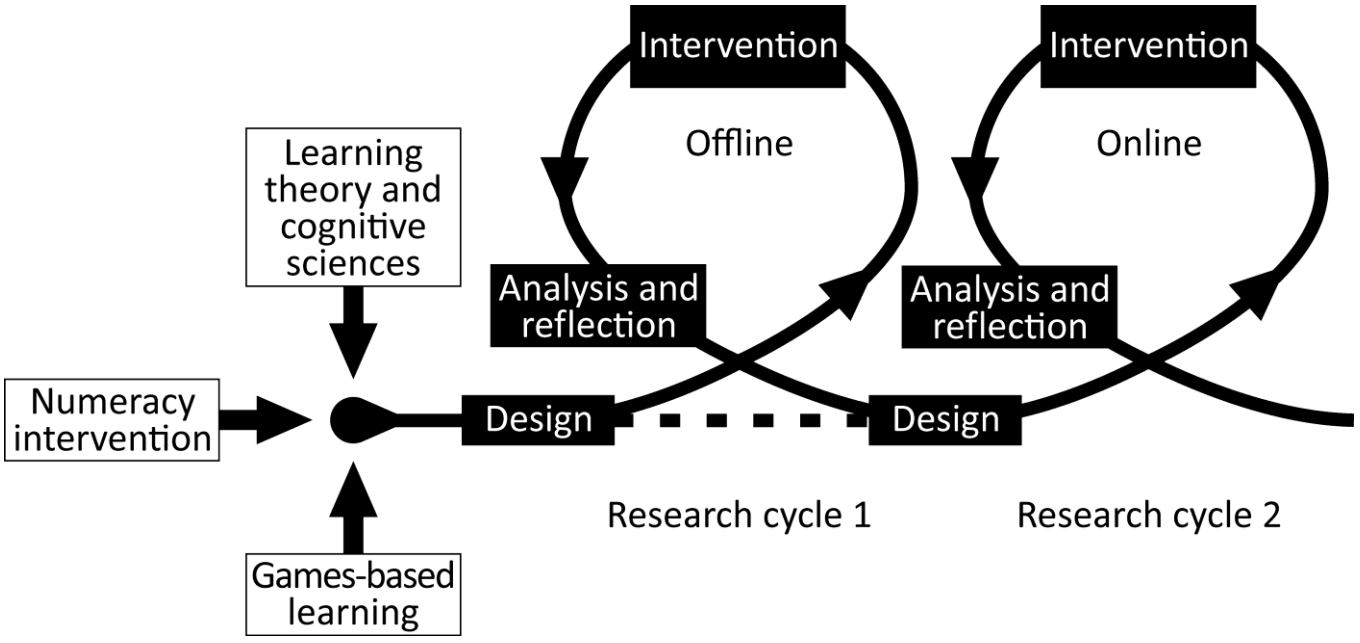

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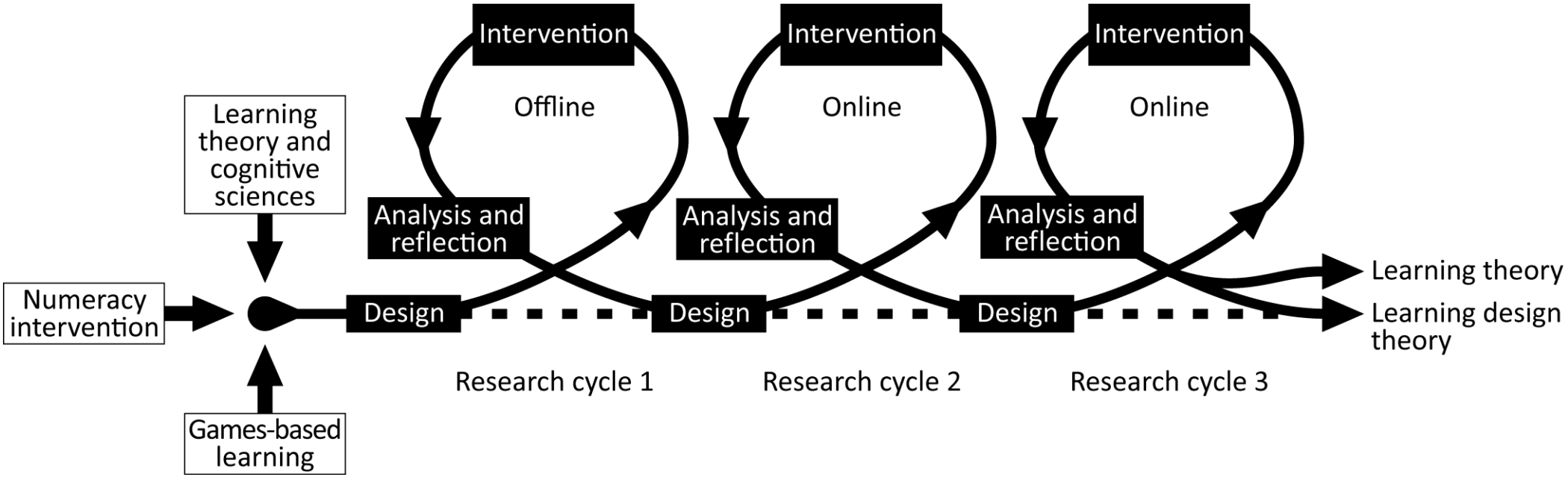

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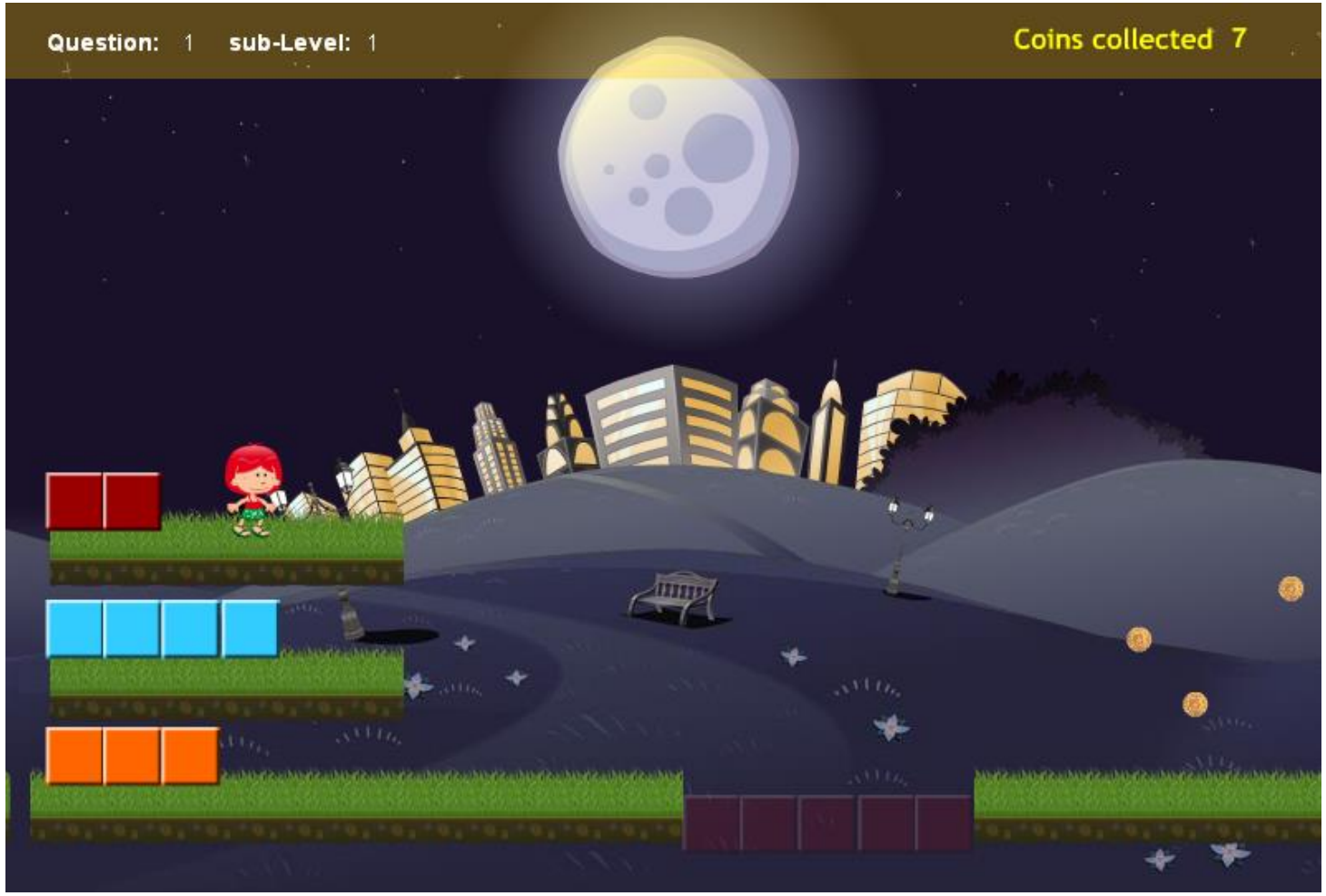

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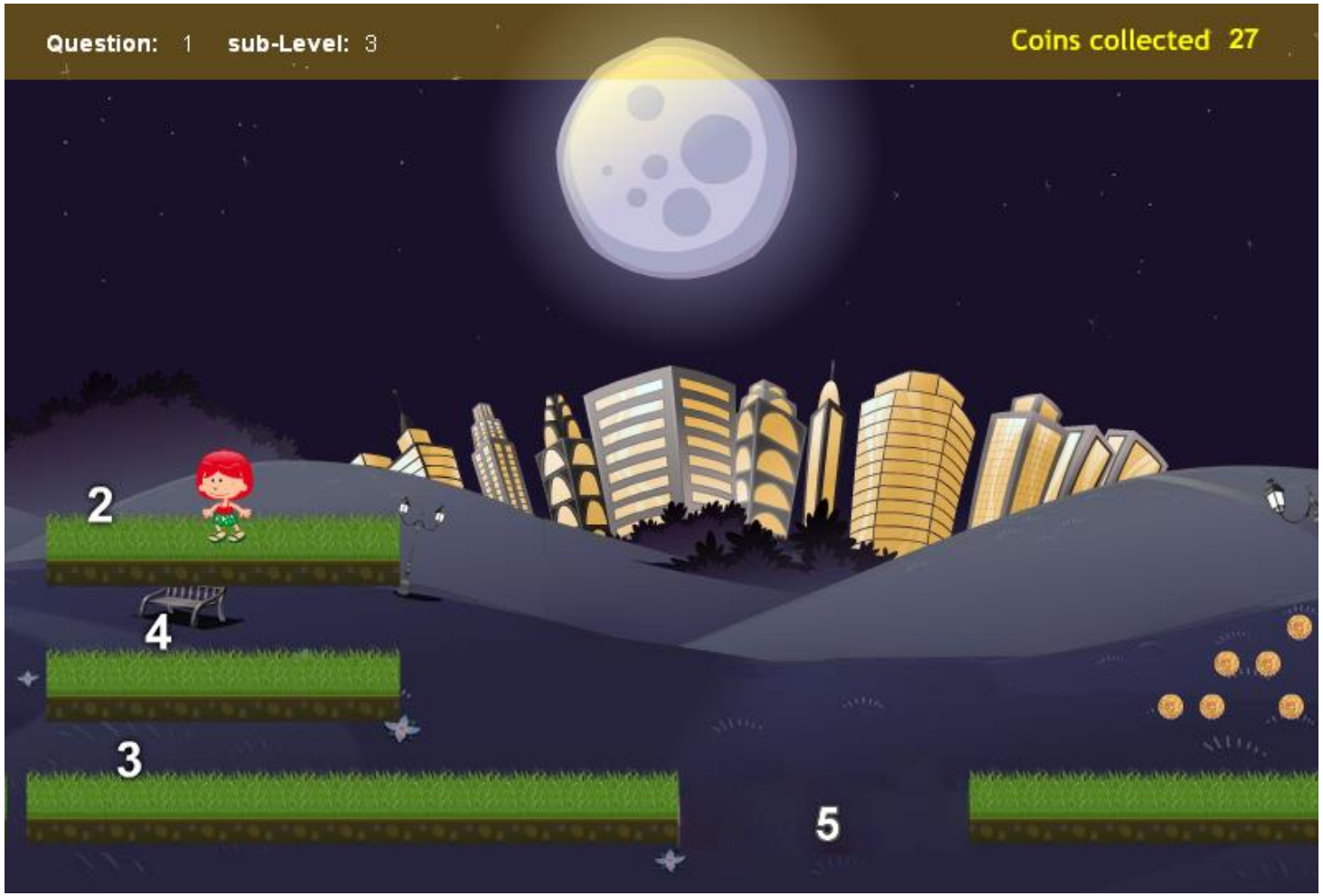


PhD THESIS PROJECT

'Level Up! A Design-based Investigation of a Prototype Digital Game for Children who are Low-attaining in Mathematics.'

UNIVERSITY OF OXFORD

OUTCOMES

- A game that implements **principles of an effective numeracy intervention** and that draws on **insights from learning theory and the cognitive sciences** can be useful in schools for children who are low attaining in mathematics.
- For it to be taken up by schools, the game has to be perceived by teachers to have achieved a **quality threshold**.

PhD THESIS PROJECT

'Level Up! A Design-based Investigation of a Prototype Digital Game for Children who are Low-attaining in Mathematics.'

UNIVERSITY OF OXFORD

OUTCOMES

- Where the prototype game was shown to be most useful is when:
  - it serves as a **fulcrum for social interaction and educationally productive discussion** between the children and teaching staff
  - it becomes an artefact that both **supports individual learning** and **stimulates, scaffolds and mediates dialogue-based collaborative learning**.

ABOUT ME

Senior Teaching Associate (2014 – 2016)
Graduate School of Education, University of Bristol

Researcher (2014 – 2016)
UCL Knowledge Lab, University College London

Lecturer (2016 to date)
Institute of Educational Technology, The Open University

Co-founder (edTech entrepreneurship)
zondle (games-based learning platform with 2m users)

MY RESEARCH BEFORE THE OU

The Open University

iTalk2Learn: EU-funded (FP7), open-source intelligent tutoring platform to support maths learning for young students.

Intelligence Unleashed. An argument for AI in Education. Pearson funded report explaining AIED and what AIED can offer learning.

Solved!: Nesta funded report into the prevalence of and evidence for collaborative problem solving.

unLocke: EEF/Wellcome Trust funded, online tool informed by neuroscience designed to support children's System 2 thinking.

Mining Mathematics Big Data to Inform Technology-mediated Learning in Primary Schools, Beijing Normal University funded.

MY RESEARCH AT THE OU

CODUR: EU funded (Erasmus +), researching metrics for comparing online distance universities.

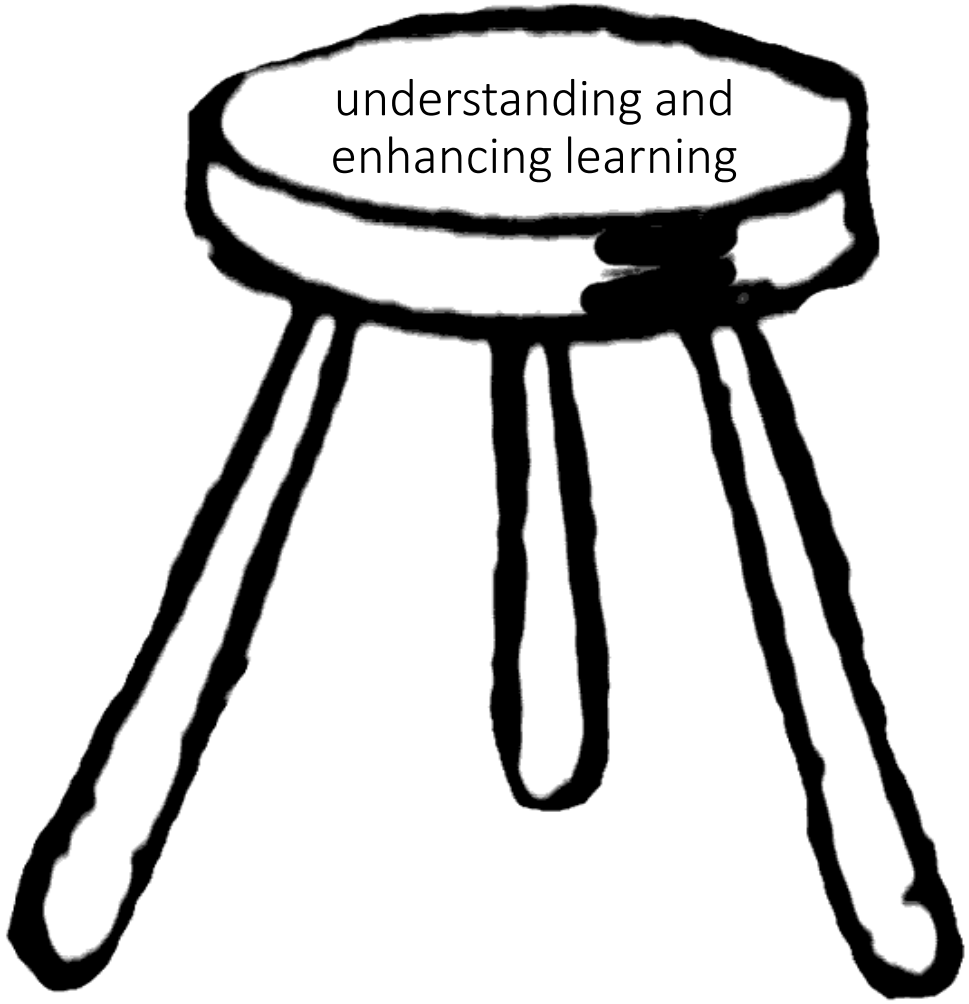
Data-informed Learning Design for Future Schools: BNU funded, using OU data comparing LD and student outcomes.

MINERVA: Innovative processes, pedagogies and technologies for OU module development and presentation.

NSS: Enhancing the OU's standing in the National Student Survey.

TeSLA: EU funded (Horizon 2020), researching adaptive system for authenticating students in online assessments.

MY PASSION: learning about learning



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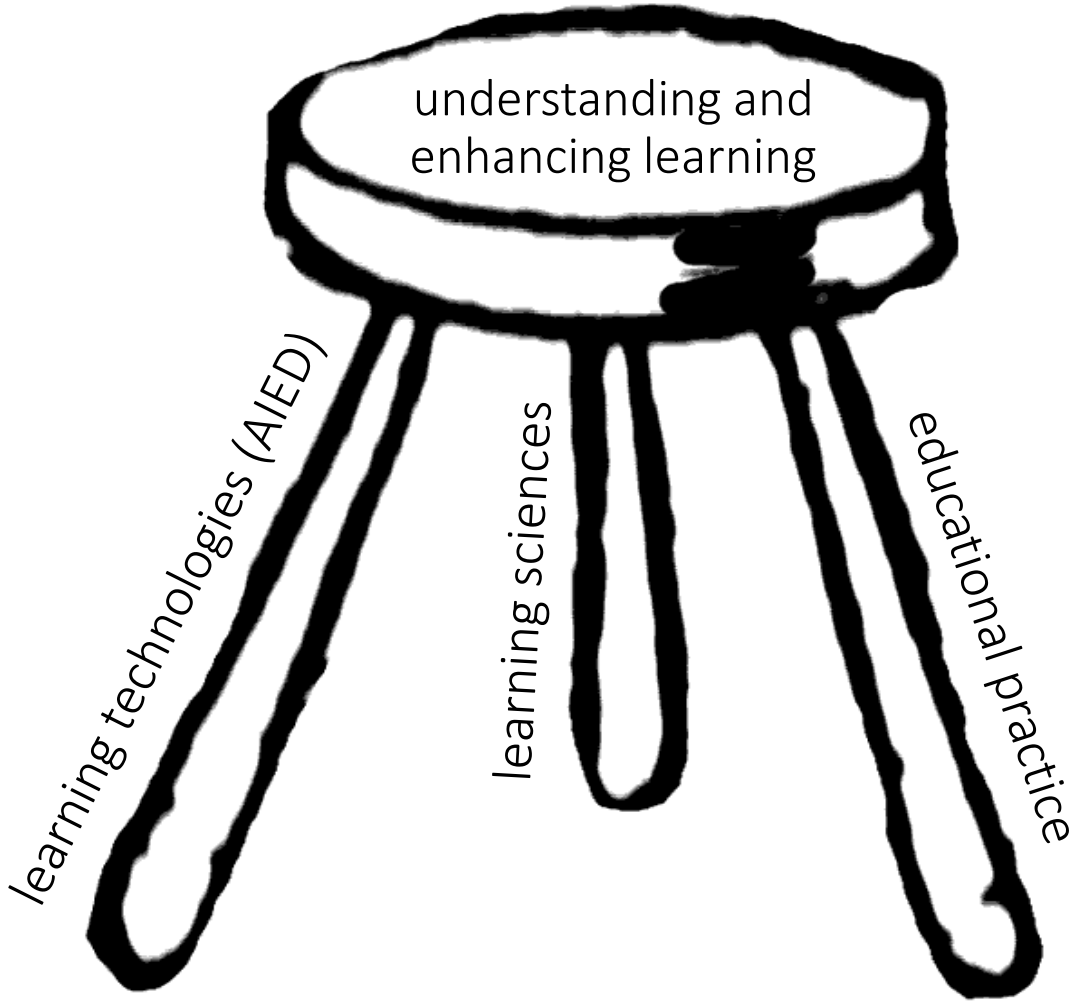


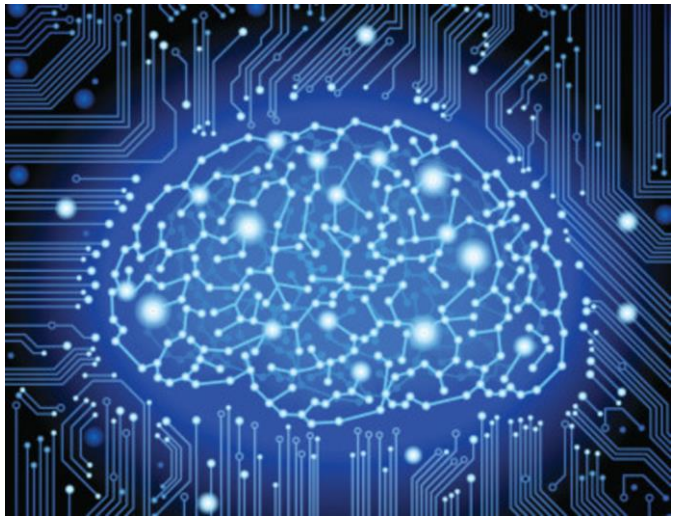
MY PASSION TRANSLATED INTO RESEARCH

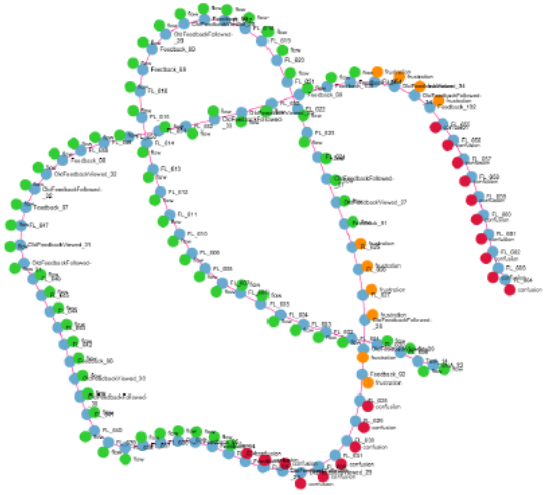
The Open University

My core research interests centre on the twin-tracks of Artificial Intelligence in Education (AIED).

AIED Track 1: Using Artificial Intelligence to **develop adaptive interventions**.

AIED Track 2: Using Artificial Intelligence to **help us learn about learning**.





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UnLocke
Learning counterintuitive concepts

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UNLOCKE

- Research* suggests that there are two distinct ways of reasoning, which co-exist and compete with each other:

  System 1 The **heuristic-based system** that is evolutionarily old, fast, automatic and parallel, and enables us to make decisions intuitively and very quickly in situations that are familiar.

  System 2 The **analytic system** that operates more slowly, is sequential, based on rules, and enables us to engage in abstract logical reasoning and hypothetical thinking.

- **The analytic system inhibits and overrides the heuristic system** when needed, so that we can think things through and carry out logical tasks, instead of giving an automatic but often incorrect response.

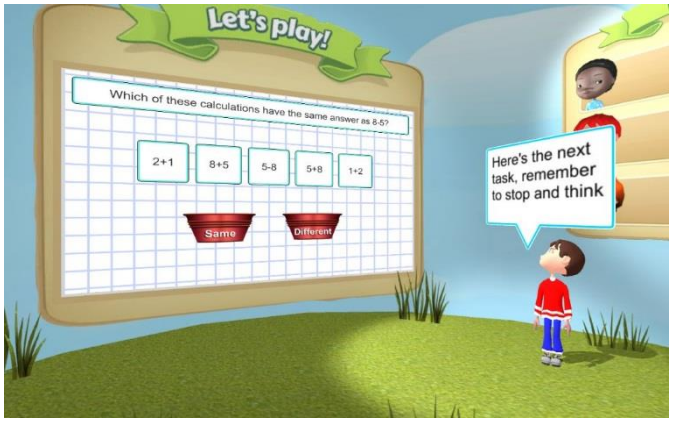
* e.g. Evans, J. S. B. T. (2003). In two minds: dual-process accounts of reasoning. *Trends in Cognitive Science, 7,* 454-459 and Kahneman, D. (2011). *Thinking, Fast and Slow.* Farrar, Straus and Giroux, New York.

UNLOCKE

- Children often demonstrate **misconceptions** when they are asked to reason about counterintuitive concepts (e.g. the sun revolves around the Earth).
- In other words:
  - they do not manage to inhibit or suppress their naïve theories, old strategies, or misleading perceptual cues;
  - they **rely mostly on their reasoning System 1**.
- For example, children often make the mistake of saying that -5 is larger than -1, because they 'automatically know' 5 is larger than 1. They find it difficult to inhibit this automatic response (and they forget what they have been taught about negative numbers).

UNLOCKE

- Misconceptions are particularly common in **maths** and **science**.
- The UnLocke intervention aims to **train children to engage their analytic system 2 and inhibit their automatic system 1**, using an approach embedded within the maths and science curricula (to aid transfer).
- The children will 'play' a gameshow-like intervention called '***Stop and Think***'.



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ITALK2LEARN

- FP7 European-funded (3 year) research project.
- Involved 4 universities (AI, computer science, education and technology, and educational psychology) and 3 commercial partners:

UCL Institute of Education

Birkbeck University of London

RUHR UNIVERSITÄT BOCHUM

RUB

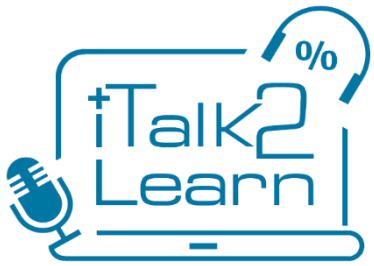
Stiftungsuniversität Hildesheim 2003

whizz EDUCATION

TESTA LUNA

SAILLABS TECHNOLOGY

ITALK2LEARN



- Designed and researched an **intelligent tutoring system** for primary school children who are learning about fractions.
- The system combined **exploratory fractions tasks** and **structured practice fractions tasks**, giving the children opportunities to engage with both the **conceptual and procedural learning of fractions**.

THE ITALK2LEARN VISION

Teacher's capabilities:

- alternates between different task types
- selects tasks of appropriate difficulty
- provides hints on student's request
- senses if a student gets stuck and intervenes
- senses if a student gets sidetracked and intervenes
- intuitive to interact with via voice and direct manipulation

THE ITALK2LEARN VISION

iTalk2Learn platform capabilities:

- alternates between different task types
- selects tasks of appropriate difficulty
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- senses if a student gets stuck and intervenes
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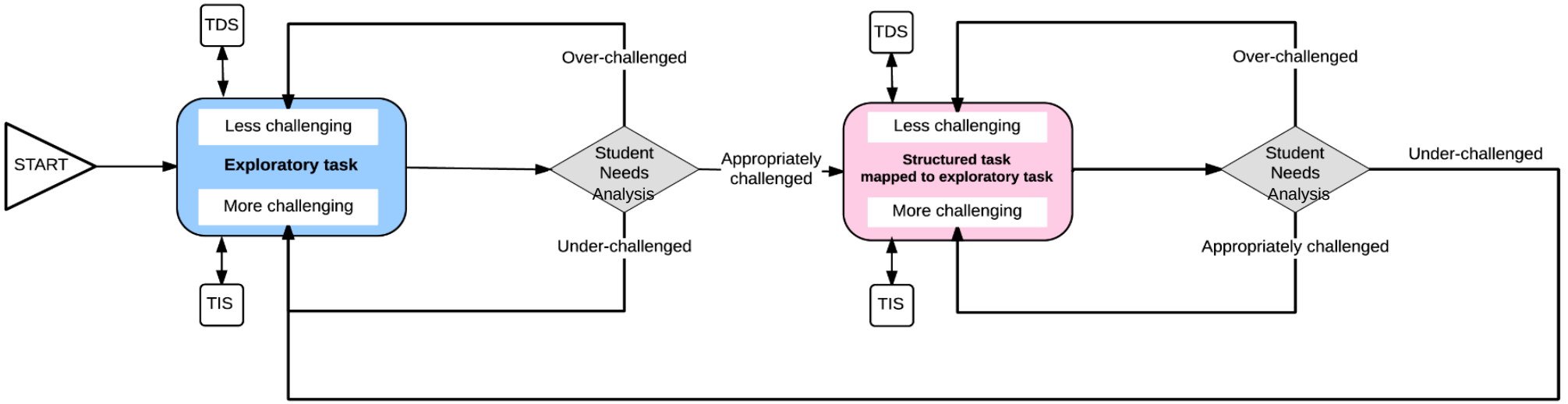
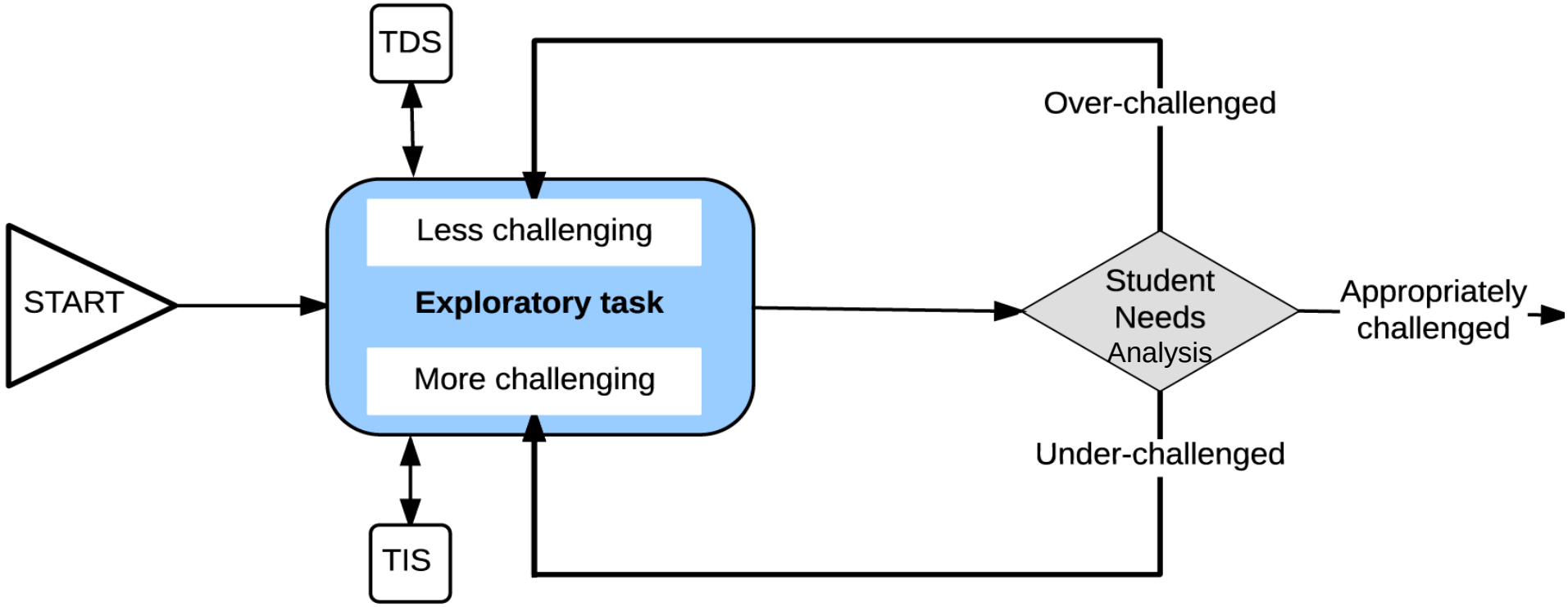
INTERVENTION MODEL



EXPLORATORY LEARNING ENVIRONMENT



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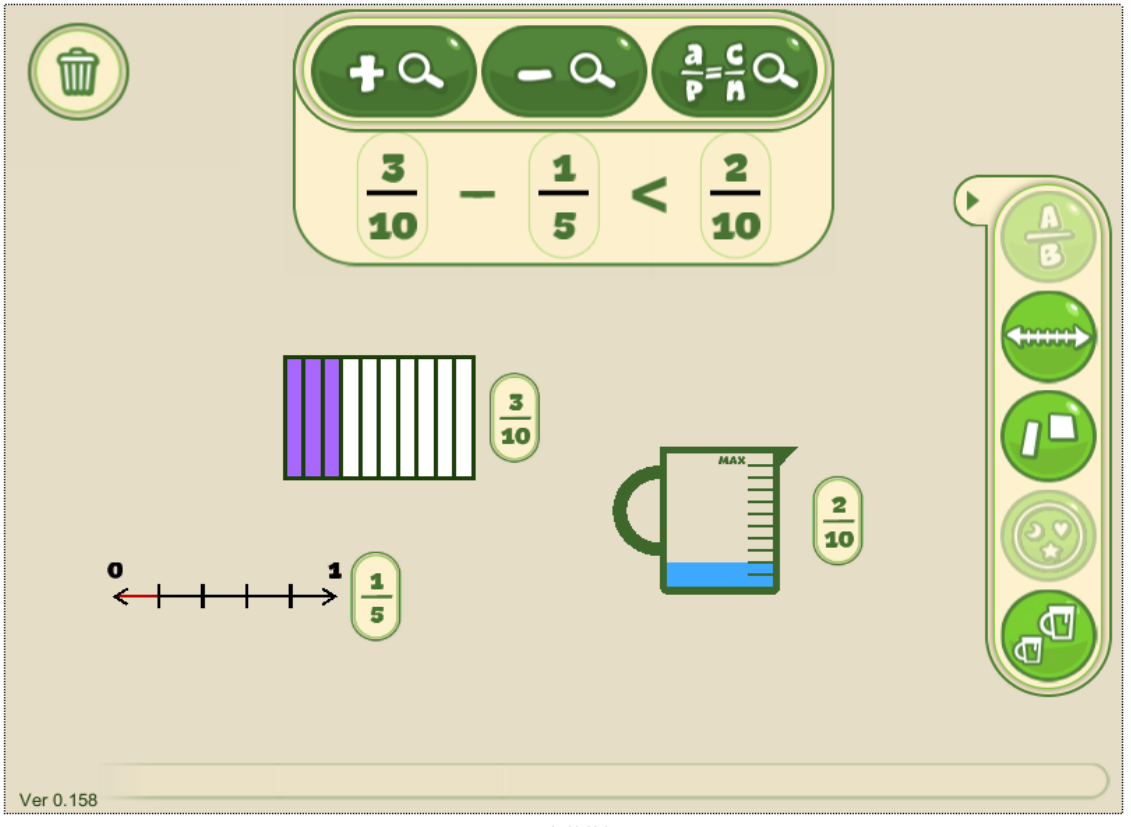


Fractions Lab

Emphasis on conceptual learning

EXPLORATORY LEARNING ENVIRONMENT

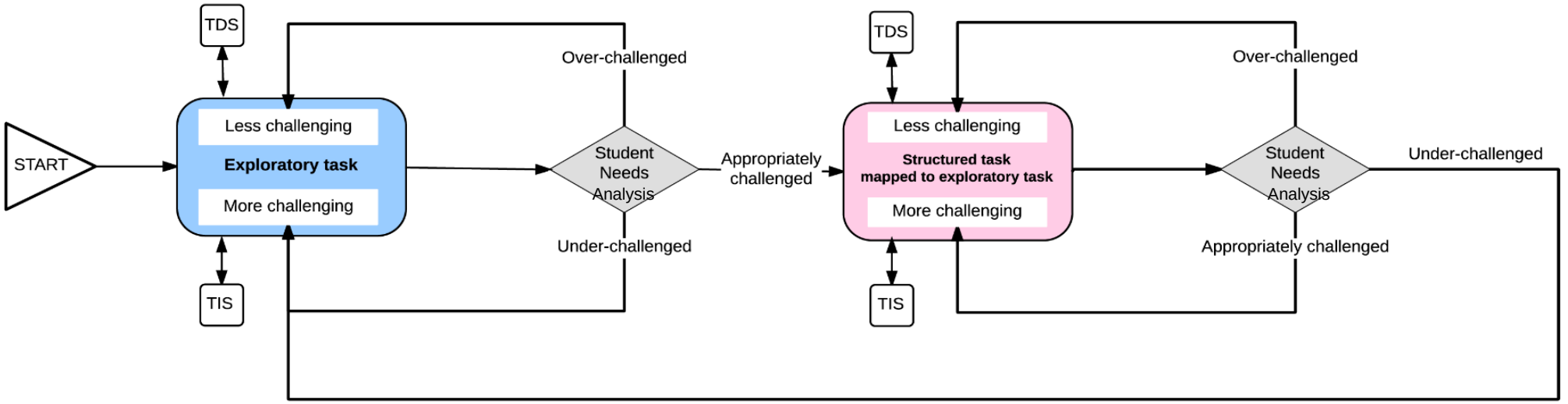
TDS (task dependent support)

TASK LEVEL EXEMPLIFICATIONS FOR TASK 2.8 (Set 2): Make a fraction that equals 3/4 and has 12 as denominator.				
IF...	THEN (Socratic)	THEN (guidance)	THEN (didactic: conceptual)	THEN (didactic: procedural)
student makes a representation with the numerator 12 or 4	*"Have you changed the numerator or denominator?"*	*"Remember that the denominator is the bottom part of the fraction."*	*"Check that you have changed the denominator, not the numerator."*	*"Check that the denominator in your fraction, not the numerator, is 12 [or 4]."*

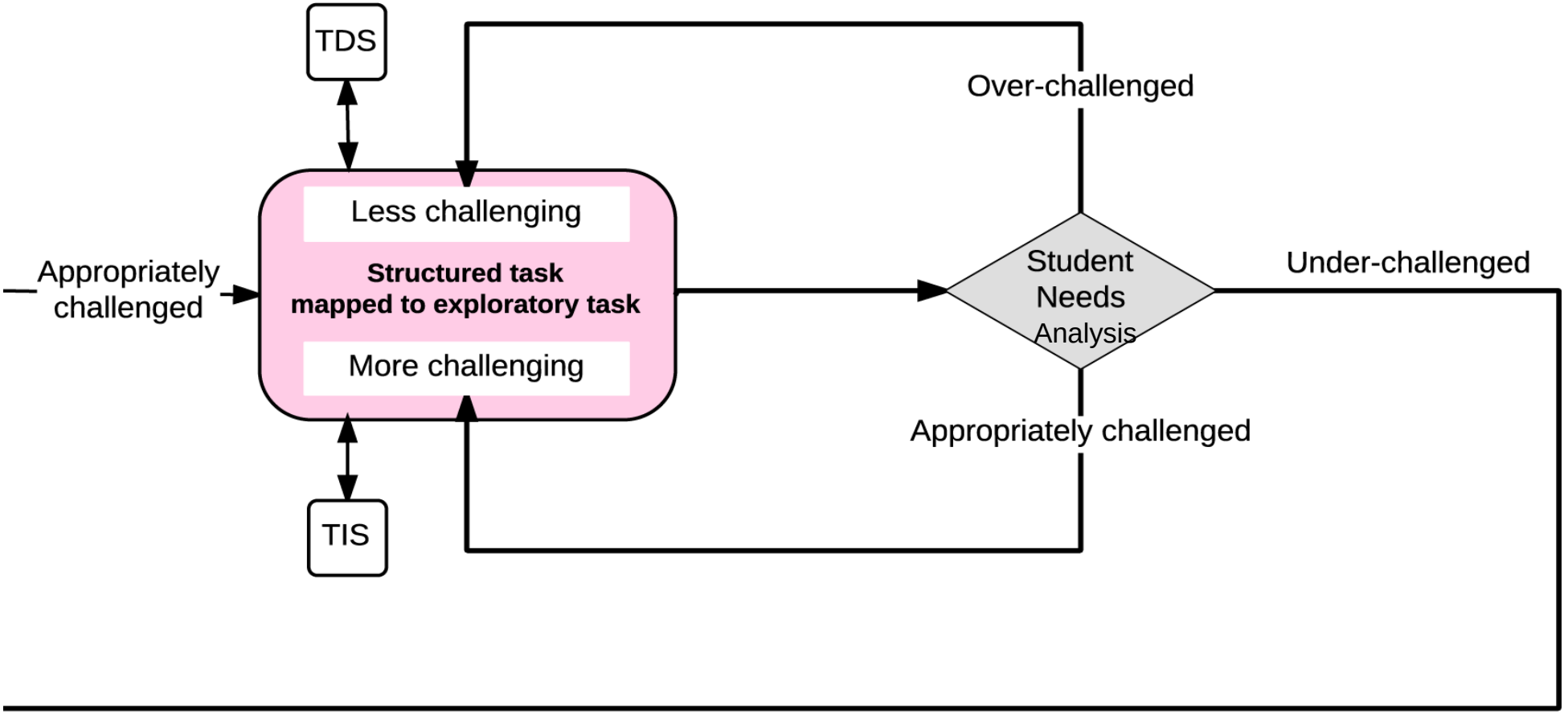
TIS (task independent support)

- Well done, you've have worked hard on this task. Why did you use this method?
- This is quite tricky. What is the task asking you to do?
- Please explain that again using the words denominator and numerator.
- Are you finding this too easy? Perhaps you should quickly finish this task, so you can tackle a more challenging task.

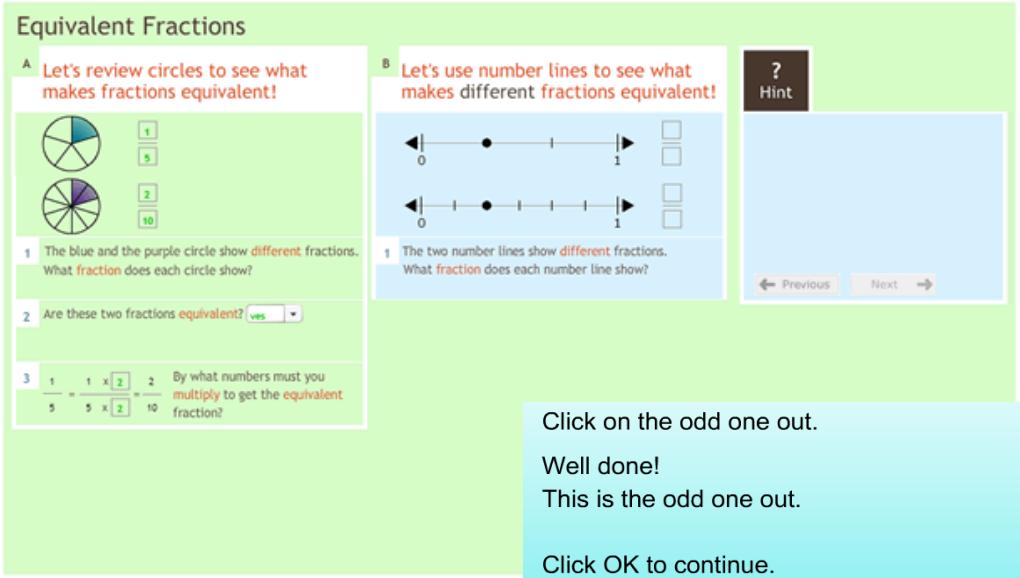
INTERVENTION MODEL



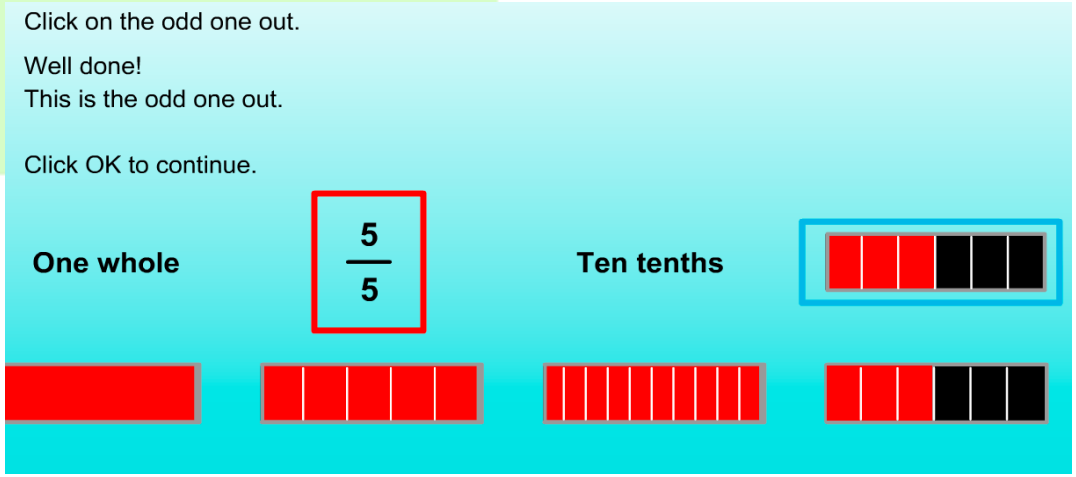
STRUCTURED PRACTICE LEARNING ENVIRONMENT



STRUCTURED PRACTICE LEARNING ENVIRONMENTS



Fractions Tutor



Whizz Maths

Emphasis on procedural learning

EXPERIMENTAL STUDIES

Germany

- 5th and 6th grade
- 10-12 years old
- 5 schools
- 243 students (in classes)
- 210 students completed

UK

- Y4 and Y5 (primary school)
- 8-10 years old
- 3 schools
- 184 students (in stratified groups)
- 177 students completed

RESEARCH HYPOTHESES

H1) Combining structured practice and exploratory tasks promotes robust learning (***combination effect***).

H2) An adaptive system that interacts with learners through speech enhances learning more than an adaptive system that does not (***speech effect***).

RESEARCH HYPOTHESES

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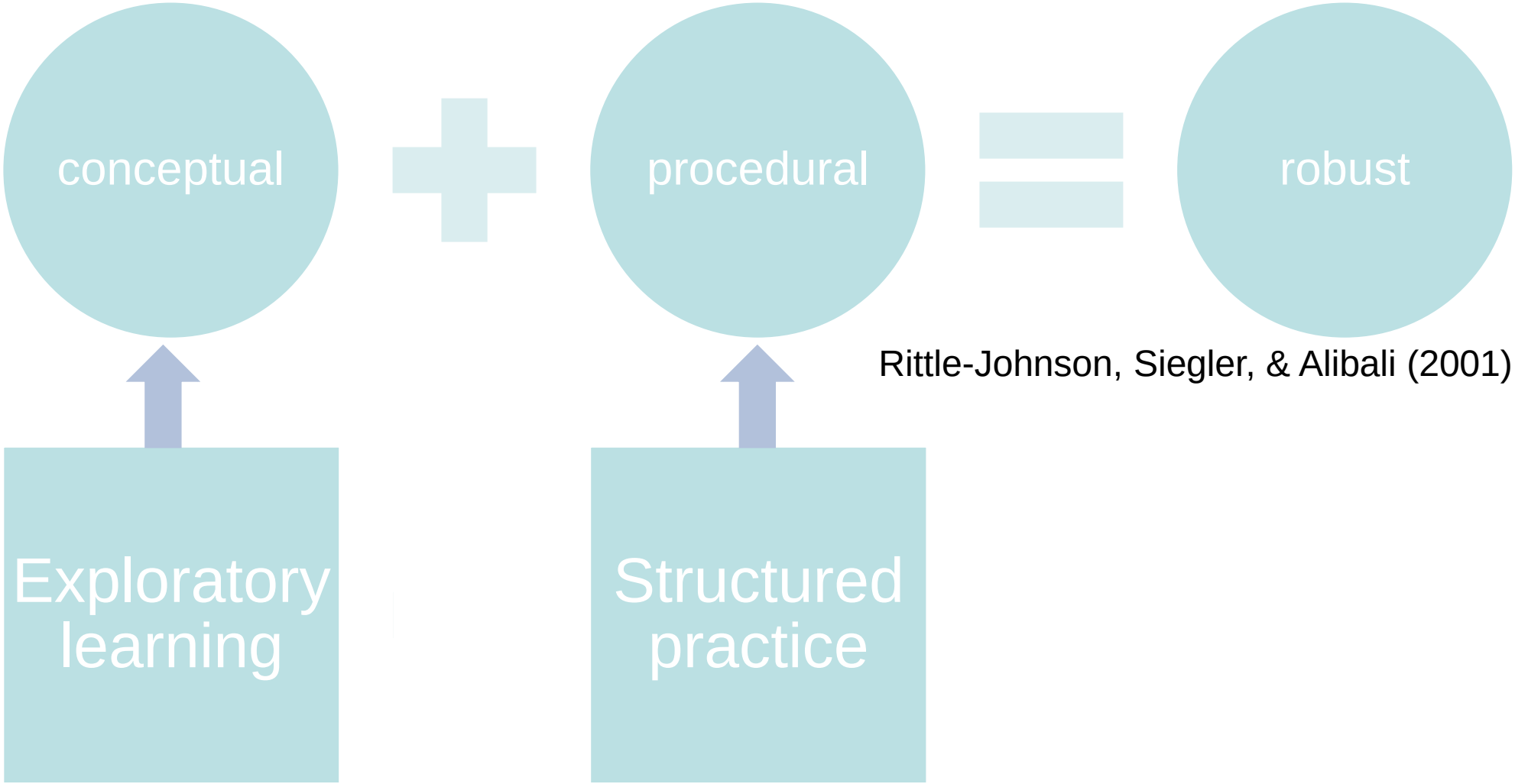
H2) An adaptive system that interacts with learners through speech enhances learning more than an adaptive system that does not (*speech effect*).

H1 RESEARCH PREMISES

Rittle-Johnson, Siegler, & Alibali (2001)

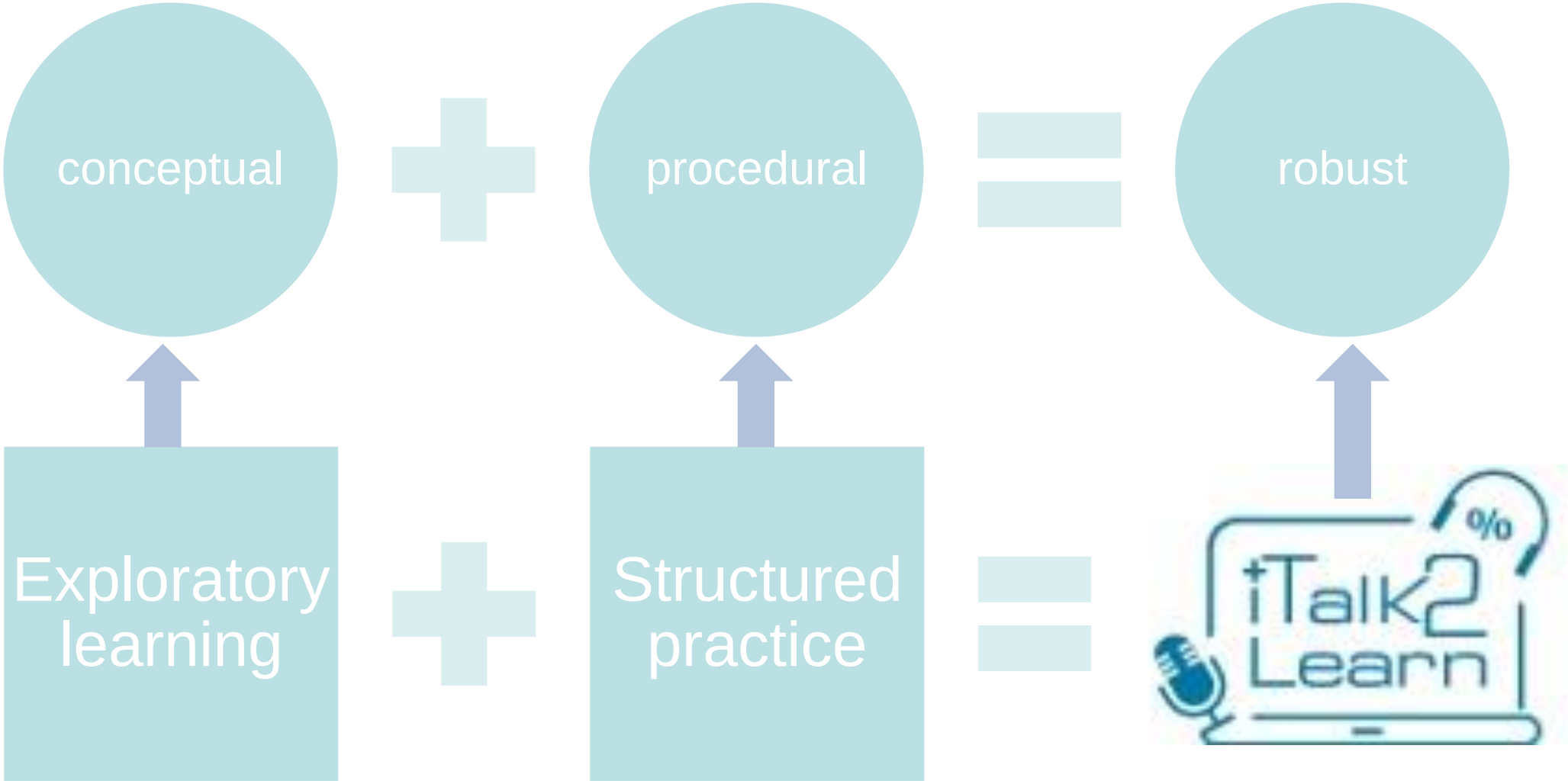
H1 RESEARCH PREMISES



Rittle-Johnson, Siegler, & Alibali (2001)

Koedinger, Corbett, & Perfetti (2012)

H1 RESEARCH PREMISES

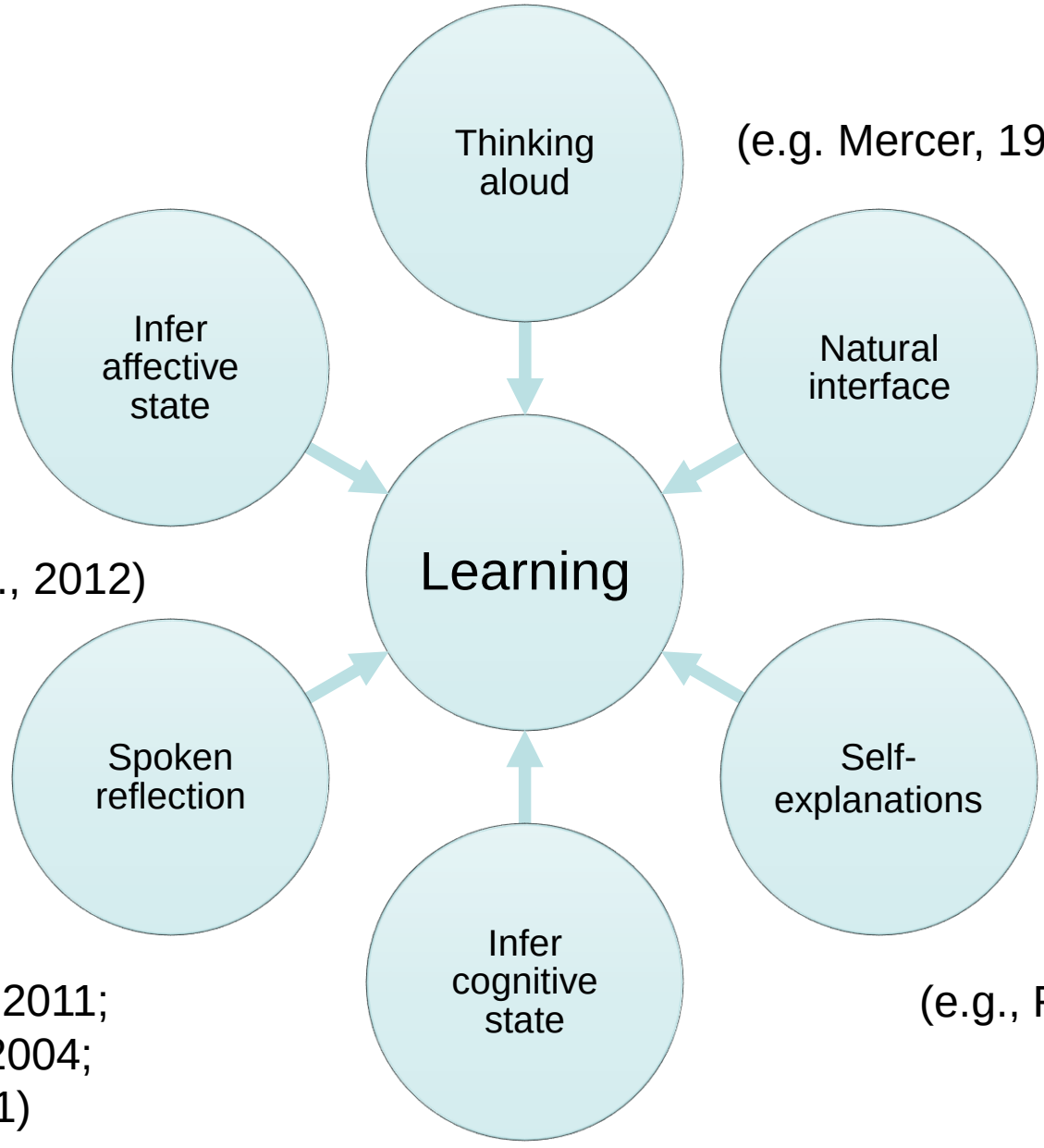


RESEARCH HYPOTHESES

H1) Combining structured practice and exploratory tasks promotes robust learning (*combination effect*).

H2) An adaptive system that interacts with learners through speech enhances learning more than an adaptive system that does not (*speech effect*).

H2 RESEARCH PREMISES



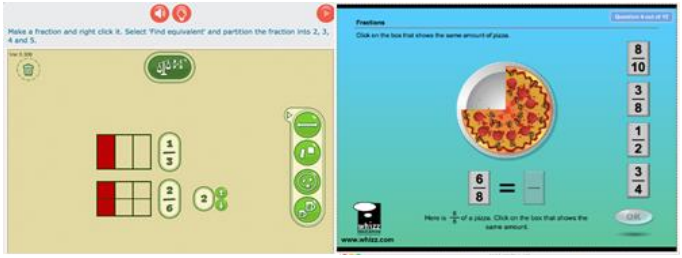
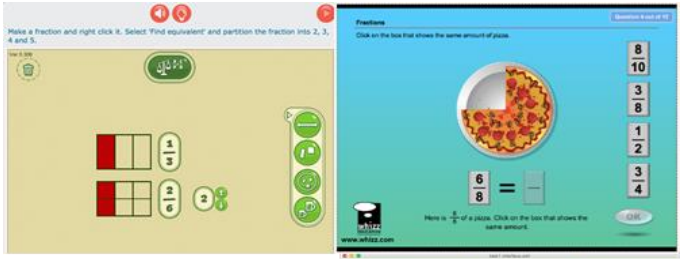
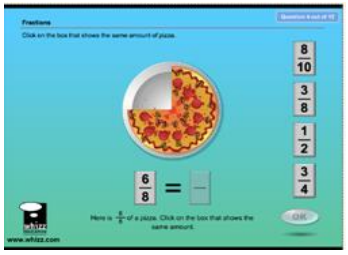
(e.g. Mercer, 1995)

(e.g. Rajala et al., 2012)

(e.g. D`Mello et al., 2011; Litman & Silliman, 2004; Mostow & Aist, 2001)

(e.g., Freudenthal, 1981)

EXPERIMENTAL DESIGN

	Speech functionality	NO speech functionality
Exploratory learning environment	  **C1: Speech condition (full platform)**	 **C2: Non-speech condition**
NO exploratory learning environment	  **C3: Speech condition (no ELE)**	

EXPERIMENTAL DESIGN

In the **speech condition (C1)**:

- students encouraged to ‘think aloud’;
- students provided with formative feedback adapted to affective state;
- affective state inferred (via Bayesian network) from speech (key words) and interaction;
- cognitive state (under-, appropriately or over-challenged) inferred from speech (prosodic cues such as the length of spoken vowels) and the amount of feedback.

In the **non-speech condition (C2)**:

- students provided with formative feedback based only on task performance;
- cognitive state (under-, appropriately or over-challenged) inferred from amount of feedback.

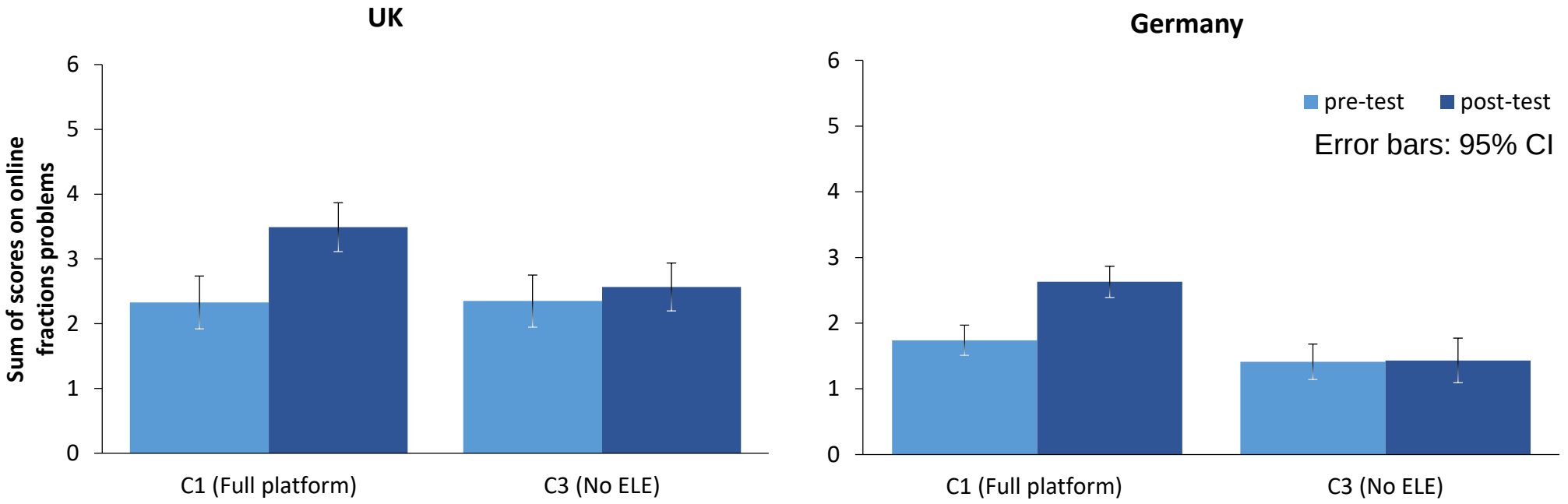
PROCEDURE

H1 SUMMARY RESULTS

Country	Effect	*df*	*F*	*p*	
Germany	Time	1,207	37.785	<.001	.164
	Time x Condition	2,207	8.447	<.001	.075
	C1 & C2 vs. C3	1,207	64.535	<.001	.238
	C1 vs. C2	-	-	-	-
UK	Time	1,174	41.894	< .001	.194
	Time x Condition	2,174	6.600	.002	.071
	C1 & C2 vs. C3	1,174	5.048	.026	.028
	C1 vs. C2	1,174	<1		

C1: Speech condition (full platform)
C2: Non-speech condition
C3: Speech condition (no ELE)

H1 SUMMARY RESULTS

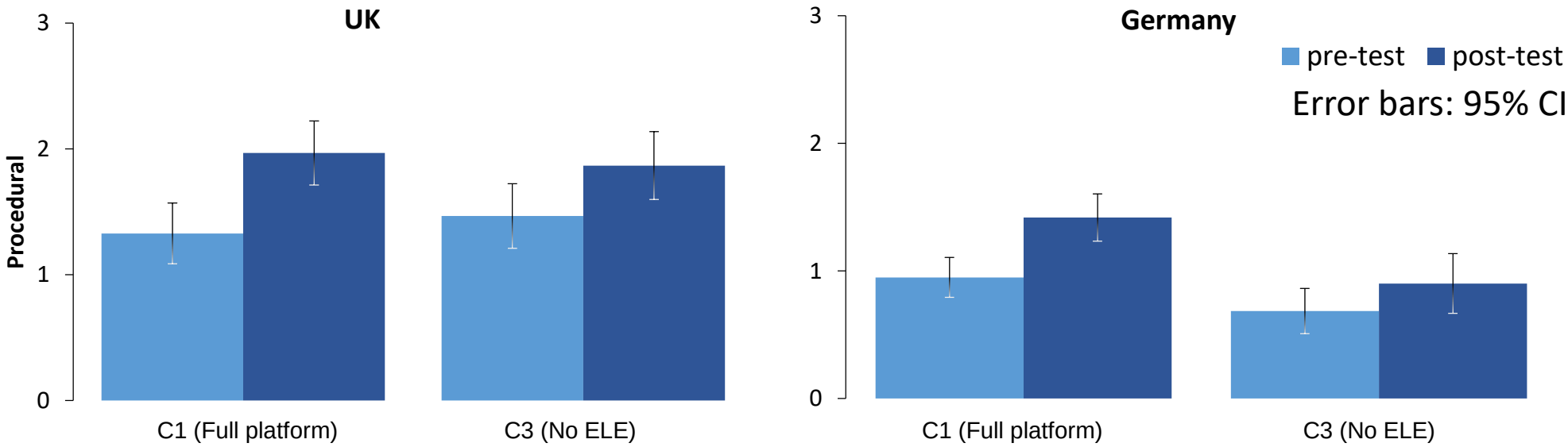


C1: Speech condition (full platform)
C3: Speech condition (no Exploratory Learning Environment)

H1 RESULTS (PROCEDURAL AND CONCEPTUAL)

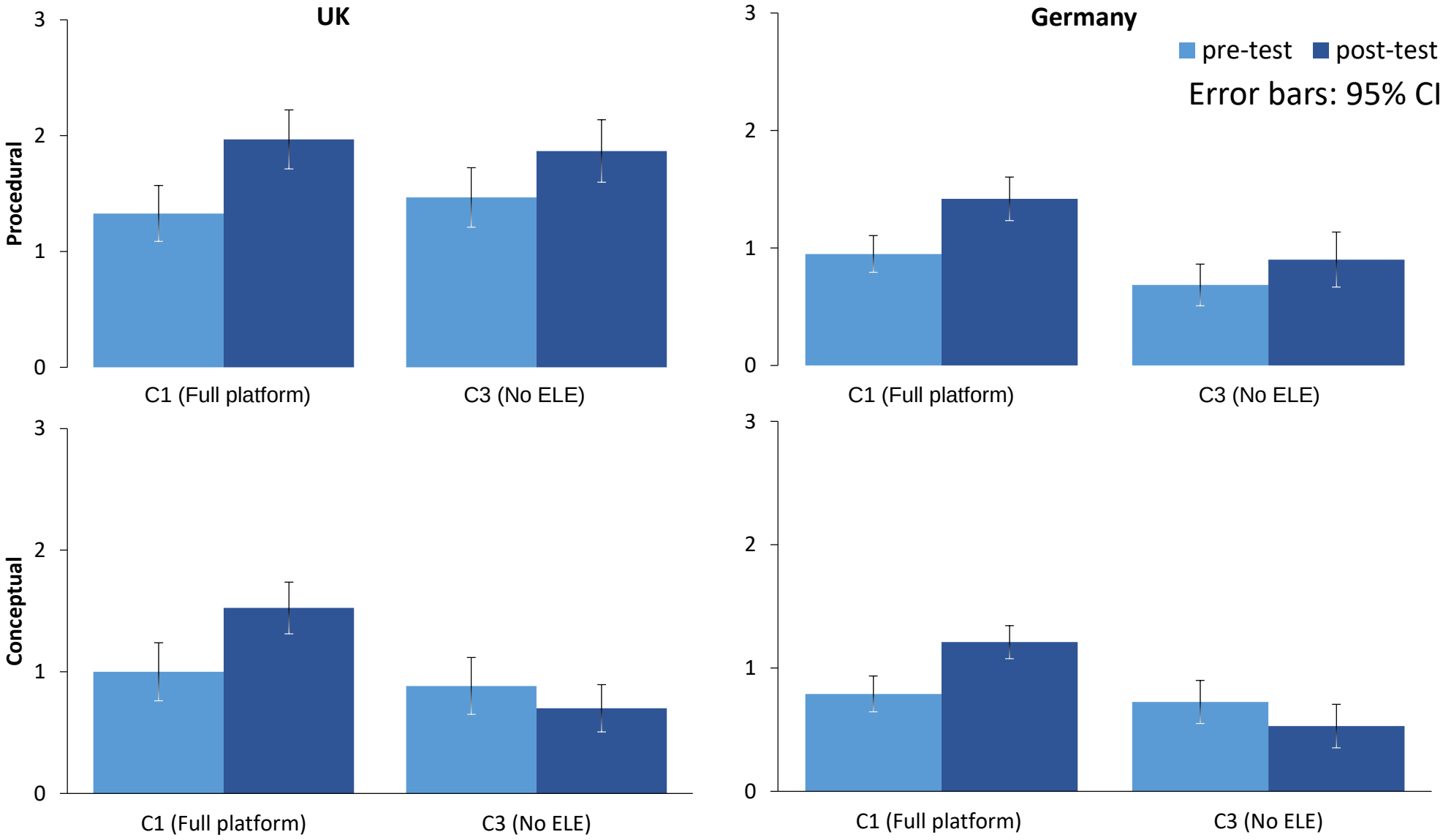
Score	Country	Condition	Pre-test		Post-test		Effect size	
			M	*SD*	*M*	*SD*	*d*	95% CI
Conceptual	DE	Full Platform	0.79	0.74	1.21	0.69	0.59	[0.30, 0.87]
		No ELE	0.73	0.63	0.53	0.64	-0.32	[-0.71, 0.07]
	UK	Full Platform	1.00	0.95	1.52	0.85	0.58	[0.22, 0.94]
		No ELE	0.88	0.92	0.70	0.77	-0.21	[-0.57, 0.15]
Procedural	DE	Full Platform	0.95	0.80	1.42	0.94	0.54	[0.26, 0.82]
		No ELE	0.69	0.65	0.90	0.85	0.28	[-0.11, 0.67]
	UK	Full Platform	1.33	0.96	1.97	1.02	0.65	[0.28, 1.01]
		No ELE	1.47	1.02	1.87	1.07	0.38	[0.02, 0.74]

H1 RESULTS (PROCEDURAL)



C1: Speech condition (full platform)
C3: Speech condition (no Exploratory Learning Environment)

H1 RESULTS (PROCEDURAL AND CONCEPTUAL)



H1 DISCUSSION

Hypothesis H1:

Combining structured practice and exploratory tasks promotes robust learning (combination effect).

Outcomes:

- Combination fosters conceptual knowledge
- Combination does not hinder procedural knowledge acquisition even though learning time is split
- Data (two countries, two structured learning environments, two age groups) supports the combination effect

H2 RESULTS

ANOVAs with **time of measurement** as the within-subjects factor and **condition** as the between-subjects factor revealed:

DE Learning gains were higher in the speech condition (d = .75) than in the non-speech condition (d = .69).
Difference not statistically significant (F(1,157) < 1, p = .727, ηp^2 = .001).

UK Learning gains were higher in the speech condition (d = .75) than in the non-speech condition (d = .44).
Difference not statistically significant (F(1,115) = 2.762, p = .099, ηp^2 = .023).

Country	Condition	Pre-test		Post-test		Effect size	
		M	*SD*	*M*	*SD*	*d*	95% CI
Germany	Speech	1.74	1.17	2.63	1.21	0.75	[0.32, 1.15]
	Non-speech	2.86	1.33	3.83	1.46	0.69	[0.17, 1.22]
UK	Speech	2.33	1.62	3.49	1.50	0.75	[0.22, 1.26]
	Non-speech	2.64	1.67	3.36	1.55	0.44	[-0.08, 0.98]

H2 DISCUSSION

Hypothesis H2:

An adaptive digital platform with speech functionality enhances learning more than the same system without speech functionality.

Outcomes:

- The students' learning outcomes did appear to benefit from the speech functionality (but neither the UK nor German result was significant).
- Encouraging students to speak during learning (to 'think aloud') and using that speech to help infer indications of the student's cognitive and affective states, in order to determine an appropriate sequence of tasks and appropriate formative feedback, did appear to contribute both to student engagement and to learning gains.

FINAL THOUGHTS...

MY RESEARCH AIMS
and OPPORTUNITIES FOR COLLABORATION

The Open University

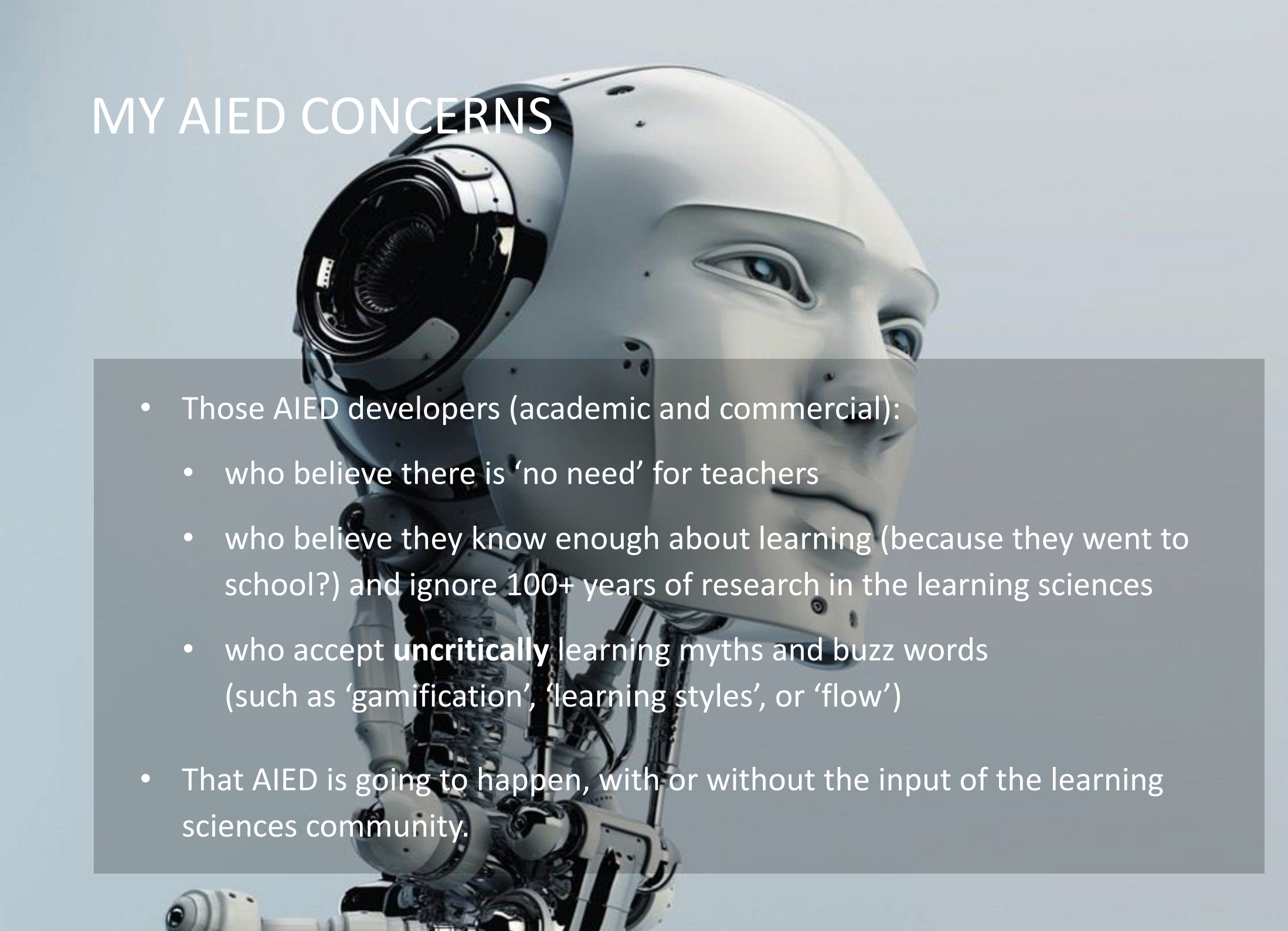
AIED Track 1: To investigate further adaptive interventions:

- **Adaptive formative feedback**.
- Life-long AI **learning companions** for students.
- AI **teaching assistants** to support teachers.
- AI enabled **assessment without exams**.

AIED Track 2: To investigate further how AI techniques might help us learn more about learning:

- Data-mining to identify **patterns of effective learning designs**.
- Data-mining and graph-based modelling to **reveal learning trajectories** and potentially **identify unrecognised misconceptions**.

MY AIED CONCERNS



- Those AIED developers (academic and commercial):
  - who believe there is ‘no need’ for teachers
  - who believe they know enough about learning (because they went to school?) and ignore 100+ years of research in the learning sciences
  - who accept **uncritically** learning myths and buzz words (such as ‘gamification’, ‘learning styles’, or ‘flow’)
- That AIED is going to happen, with or without the input of the learning sciences community.

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Thank you for listening. I welcome your questions.

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