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The LCT Centre For Knowledge-Building

CPHC Conference 2024

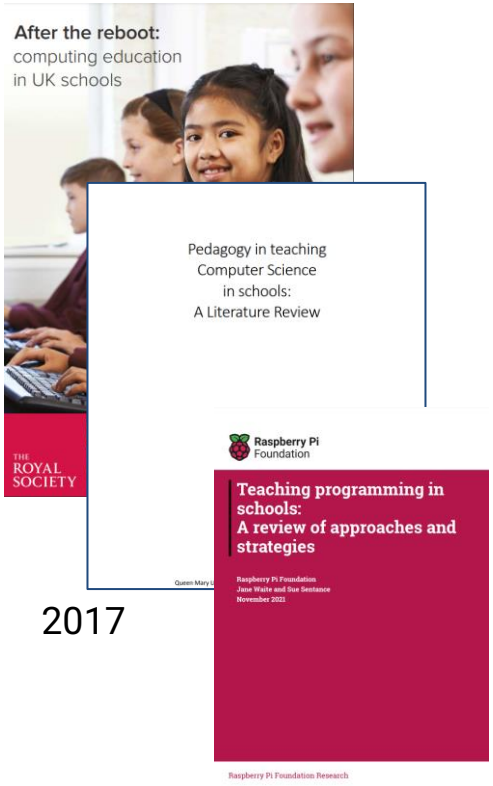
Computing pedagogy

Jane Waite

RASPBERRY PI
COMPUTING EDUCATION
RESEARCH CENTRE

Queen Mary University of London

2 years ago, at the CPHC conference …



2017

2021

CPHC Conference 2022

Exploring Pedagogy in CS Education

Activity A

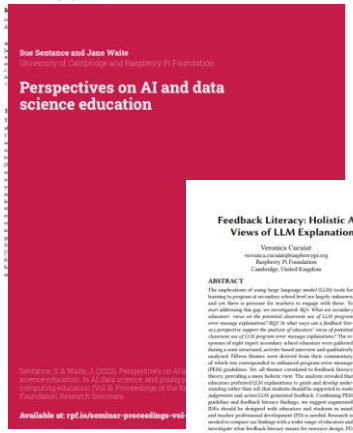
Instructional approach opportunities

Activity A: Instructional approach opportunities

Instructional approach	I/we use this 1. Never 2. Occasionally 3. Usually 4. Always	I/we would like more information 1. No thanks 2. Yes, but not priority 3. Yes, this looks useful	I/we have expertise in this approach 1. Yes, but we can't share 2. Yes, and we can share
Semantic waves			
Unplugged approach			
Reading and tracing code			
Worked examples and subgoal labelling			
Parsons problems			
PRIMM (predict, run, investigate, modify make)			

Since then - we have been investigating

2022



2023

2024

- Semantic profiling
- Feedback literacy and explanations
- Can semantic profiling and/or feedback literacy help students navigate the use of LLM output?

An offer!

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Semantic waves

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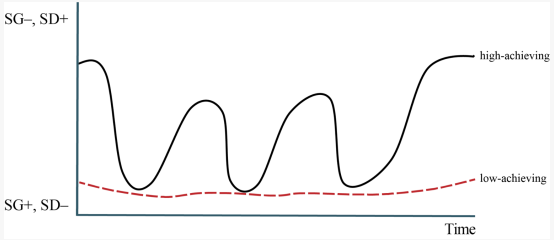

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What is Legitimation Code Theory (LCT)?

- LCT is a framework for **analysing social situations** (Maton, 2013).
- The framework includes tools to reveal the hidden “rules of the game”.
- Karl Maton, creator of LCT, builds on the work of Bernstein and Bourdieu. http://legitimationcodetheory.com/theory/introducinglct/
- There are a number of dimensions, one of which is called Semantics.
- Semantic Profiling has been used to analyse learning in many subjects (Blackie, 2019; Love, 2016).

Other researchers working in the general Semantics space

The work of Steve Kirk on English for Academic Purposes https://www.durham.ac.uk/staff/s-e-kirk/#publications (University of Durham - HE writing)

Sigsgaard, Anna-Vera Meidell; Jacobsen, Susanne Karen . 7. Scaffolding the Wave: Supporting Student Teachers in Professional Academic Writing Through LCT and SFL. Language in Action - SFL Theory across Contexts. Equinox eBooks Publishing, United Kingdom. p. 177-205 Jun 2021. ISBN 9781800500044. https://www.equinoxpub.com/home/view-chapter/?id=40632. Date accessed: 19 Feb 2024 doi: 10.1558/equinox.40632. Jun 2021 (Denmark - teacher education)

Margaret Blackie (2014) Creating semantic waves: Using Legitimation Code Theory as a tool to aid the teaching of chemistry, Chemistry Education Research and Practice, 15: 462–469.(South Africa - teaching chemistry)

Lucy Macnaught, Karl Maton, K.,James Martin,. & Erika Matruglio (2013) Jointly constructing semantic waves: Implications for teacher training, Linguistics and Education, 24(1): 50–63. (Australia - teacher training)

Bilingual education longitudinal programme of research of classroom practice at the University of Madrid https://uam-clil.org/longad-clil/ (Spain - bilingual education)

Our context

- With support from Karl, we have been applying LCT, particularly Semantic Profiling, to our work in Computer Science (CS).
- Analysed our own activities – as case studies and to review our own practice.
- Introduced Semantic Waves to **educators** who teach CS in schools, at university, in industry and in developing teaching resources.
- Introduced Semantic Waves to **undergraduates** to support their learning, e.g. to create better explanations.

Teacher facing magazine articles

FEATURE

SEMANTIC WAVES AND CRAZY CHARACTERS

Reviewing a lesson activity using semantic waves

Crazy Characters is a free online lesson plan which introduces algorithms to primary pupils using an unplugged activity. It is one of the free resources available from the Barefoot website (helloworld.cc/crazycharacters). In the activity, learners are asked to follow verbal instructions (see Figure 1) to draw a crazy, made-up character. The instructions are not very precise, so that learners can then improve the algorithm.

JANE WAITE

Jane is a research scientist at the Raspberry Pi Foundation. Her interests include using design in primary programming, semantic waves, PRIMM, and migrating to online teaching using ABC.

KARL MATON

Following a whole-class activity, learners then design their own algorithm in order to draw their own crazy character.

Where did Crazy Characters come from?

In 2012, Michael Gove disapplied the English ICT Curriculum, creating a two-year hiatus while we, primary teachers, awaited a new statutory ICT curriculum.

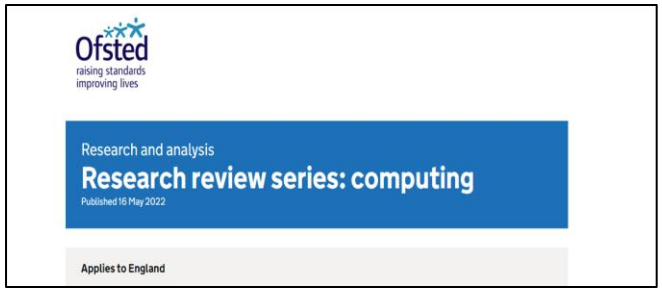
In the meantime, we were still required to deliver the old curriculum, or to start to teach what we thought might come next. I [Jane] recall being at BETT, the big computing education trade show, as the announcement was made, and then frantically searching for resources and people who could help me rewrite my school's ICT subject planning. I recently found my first revised scheme of work, which I created for September 2012 – there was no mention of algorithms, but there were learning objectives such as, 'I can predict the results of someone

Over the next year, the Barefoot team developed resources that demystified the computer science elements of the new computing curriculum. Using an iterative approach, we wrote concept documents and their associated classroom activities, publishing as we went along. The algorithms concept was first, and I was tasked with thinking of an introductory unplugged activity. In June 2014, Crazy Characters was born.

Crazy Characters was one of the first resources on the new Barefoot website, part of the very first continuing professional

job as a content author on the Barefoot Computing Programme. Managed by the British Computer Society (BCS), the initiative was funded by the DfE and BT, and was one of the first of many successful, innovative, and crucial Computing at School (CAS) programmes to support teachers in their delivery of computer science in school. Very luckily, I got the job and my life changed completely.

Guidance for teachers



Ofsted
raising standards
improving lives

Research and analysis

Research review series: computing

Published 16 May 2022

Applies to England

Chapters in researcher and teacher facing books

Raspberry Pi Foundation

Why Semantic Profiling for computer science?

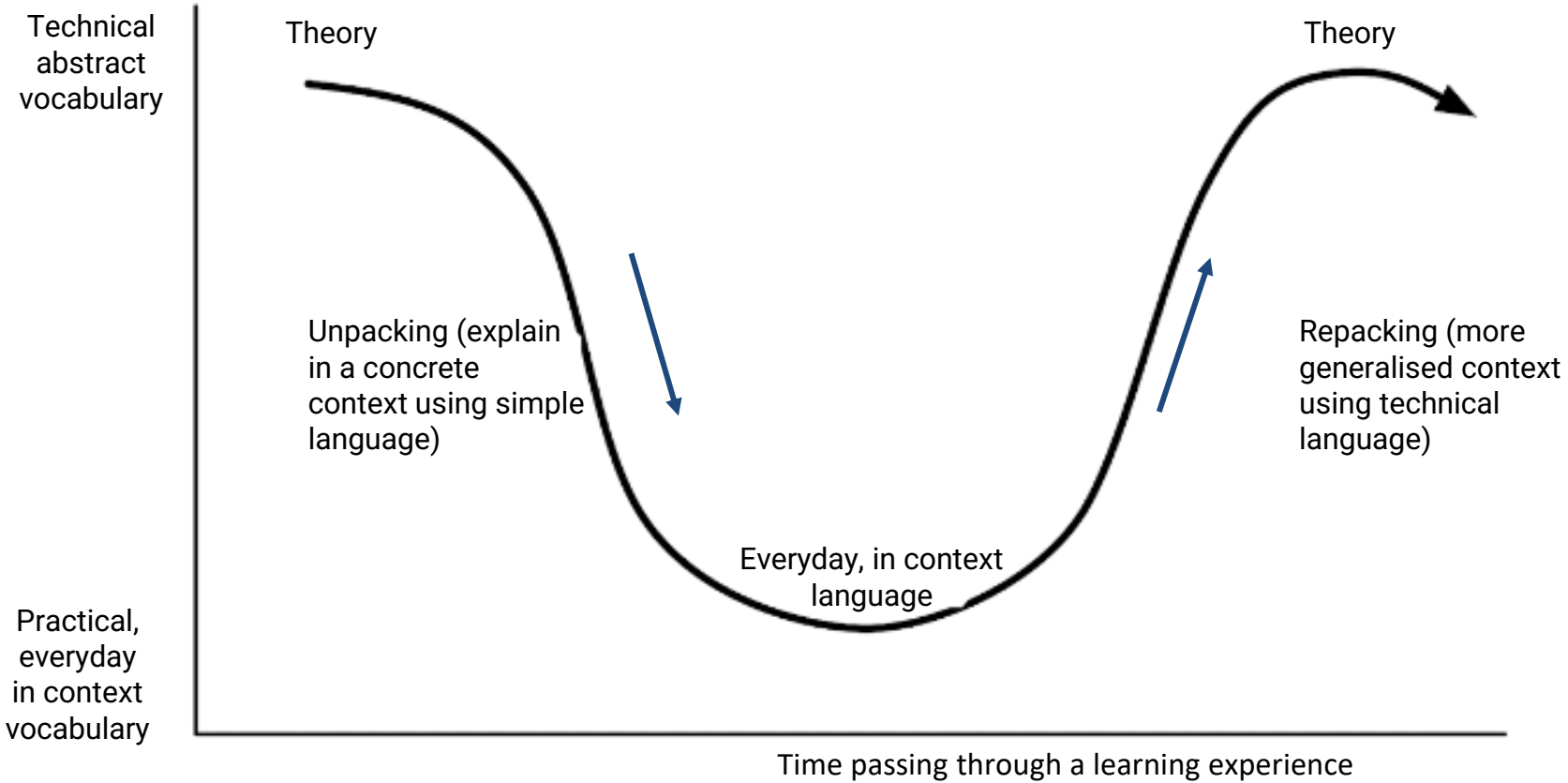
- Computer science is full of complex concepts and unfamiliar jargon.
- Notoriously hard to teach and hard to learn.
- Everyday analogies and contexts are often used to try and explain things, often unplugged.
- Or we put concepts into practice, through programming tasks.
- Impact on learning from unplugged has been mixed, and how effective some instructional approaches are for programming tasks varies.
- Let’s try profiling learning events to explore Semantic Density and Semantic Gravity as potential influencing factors.

Semantic profiling

‘Semantics’ can be used to analyse changes in a learning episode over time as a profile of:

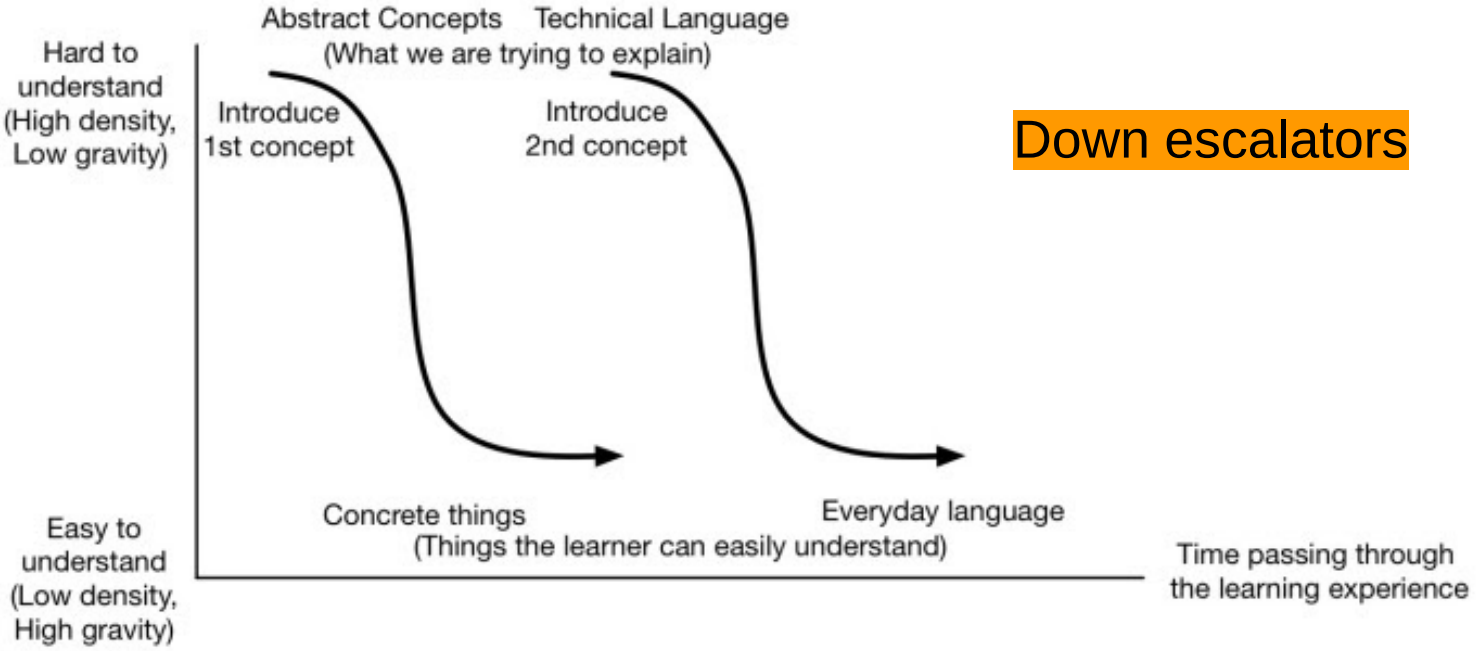
- complexity of meanings - Semantic Density
- dependency on context - Semantic Gravity

Some profiles have Semantic Waves.



(Adapted from Maton, 2013)

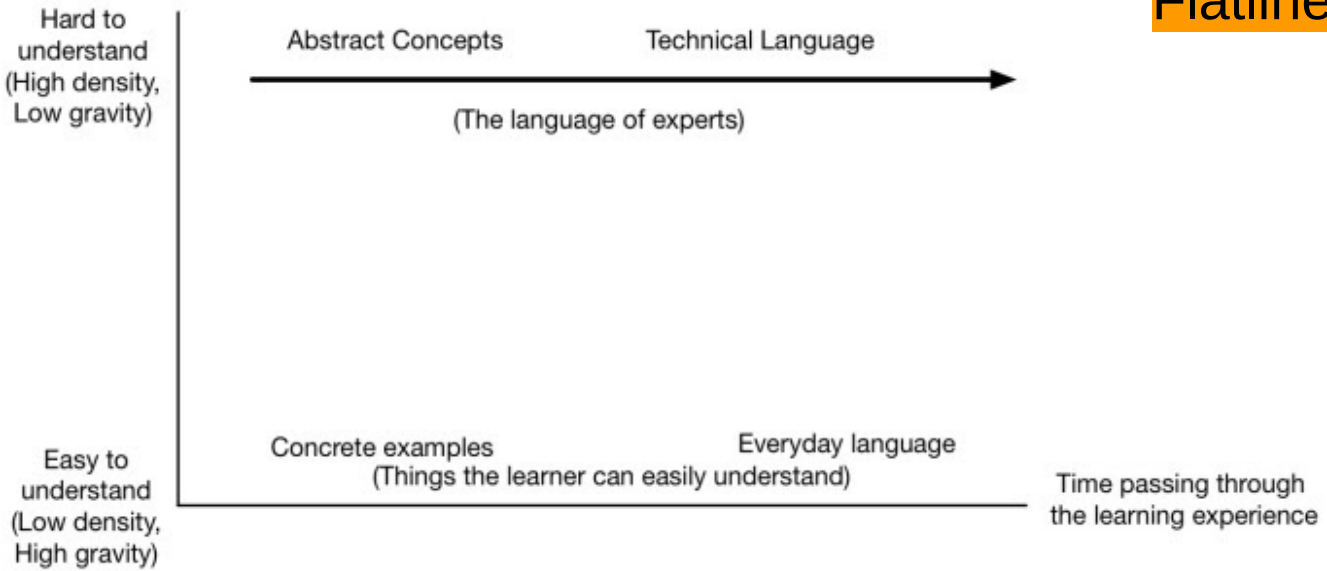
Different profiles



Down escalators

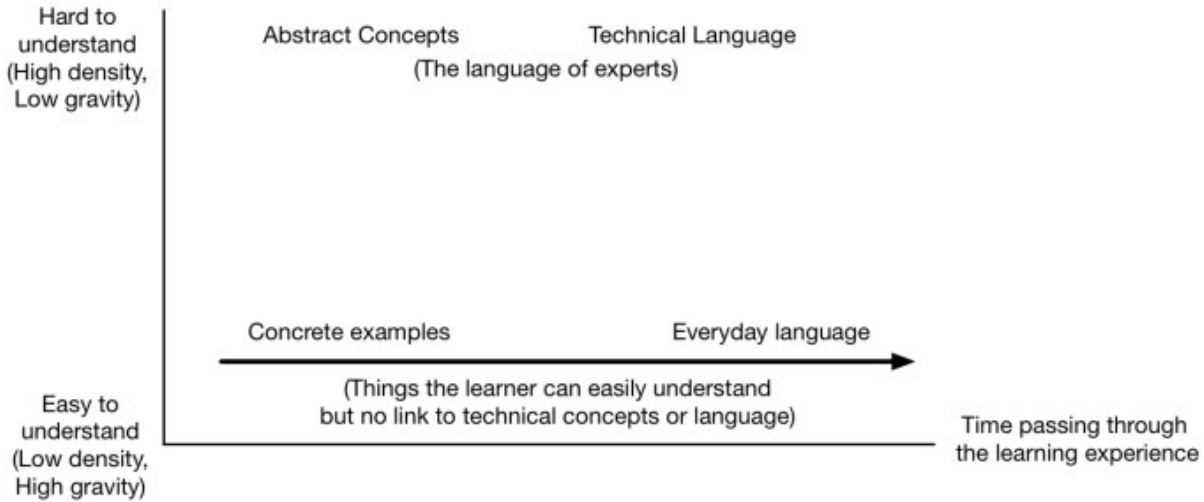
Different profiles

Flatlines

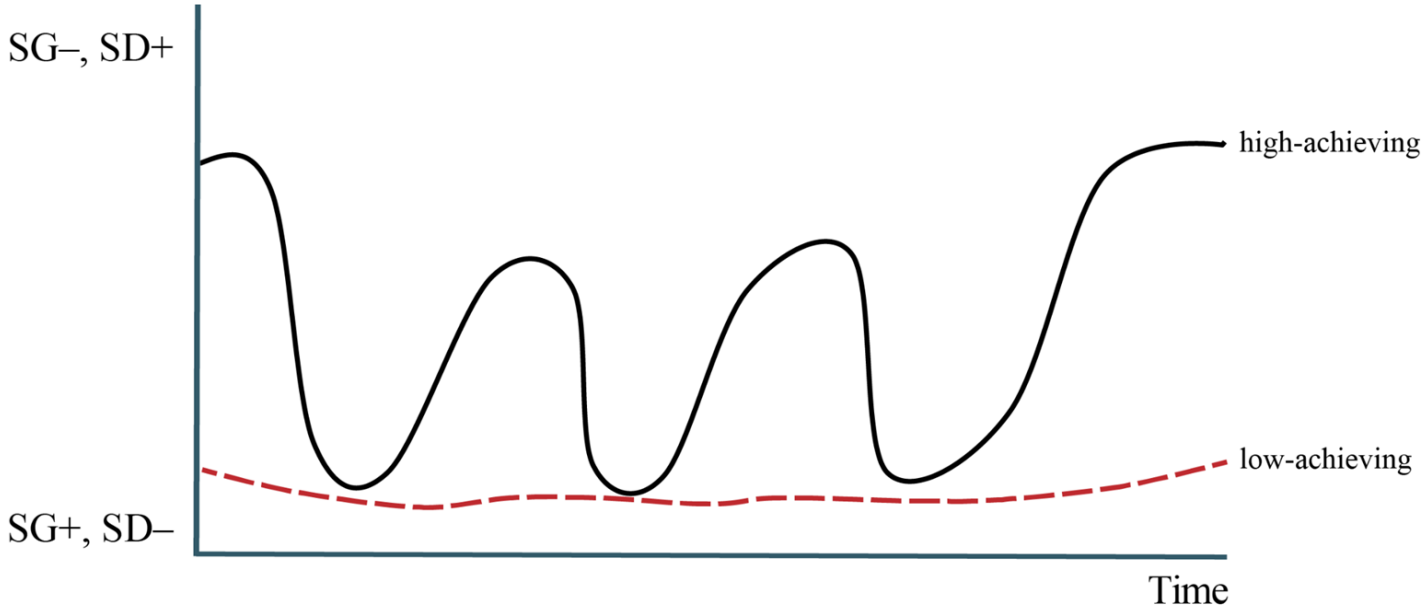


Different profiles

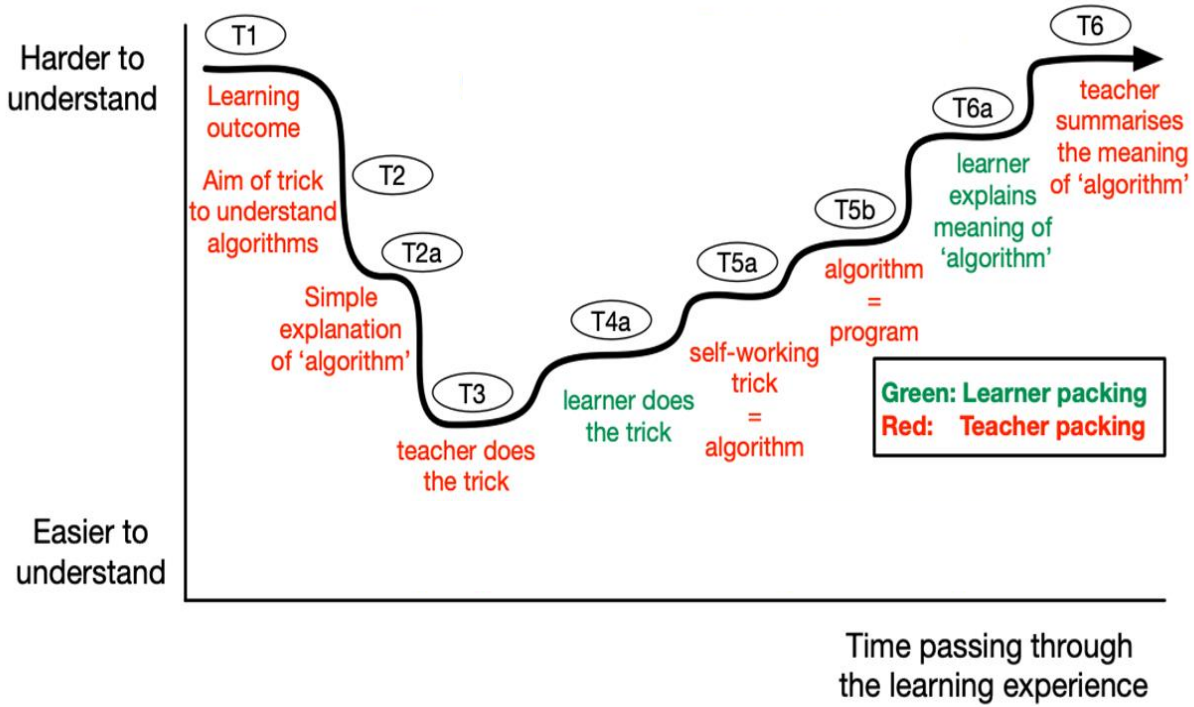
Flatlines



Comparing profiles



Semantic profile for the final plan of the teleporting robot activity.



- Is it a wave?
- How high and low do you go?
- Who is packing?

Semantic profile for the new feedback to an incorrect answer to a SQL question

Technical abstract vocabulary
No context (harder to understand)

Practical everyday vocabulary
In a context (easier to understand)

When selecting data from two tables, there must be a primary/foreign key relationship that is used to link the two tables.

This SELECT statement doesn't combine data from two tables.

Notice that you need the `QuestionText` and `PublishedDate` from the `Poll` table and the `OptionText` from the `Option` table.

The `PollId` field is used to link the `Poll` and `Option` tables. This is a primary key in the `Poll` table and a foreign key in the `Option` table. Therefore, in the WHERE clause of the SELECT statement the two tables should join on the `PollId` field.

Here is how the tables with some example data could look like:

Poll

PollId	QuestionText	IsActive	PublishedDate
1	Which is a higher risk of climate change?	True	01/10/2021

Option

OptionId	PollId	OptionText
1	1	extreme temperatures
2	1	sea level rise

Resource design - includes Semantic Profiled explanations

Artificial intelligence (AI) is the design and study of systems that appear to mimic intelligent behaviour. Some AI applications are based on rules. More often now, AI applications are built using **machine learning** that is said to 'learn' from examples in the form of **data**. For example, some AI applications are built to answer questions or help diagnose illnesses. Other AI applications could be built for harmful purposes, such as spreading fake news. AI applications do not think. AI applications are built to carry out tasks in a way that appears to be intelligent.

Resource design - Semantic Density and Semantic Gravity - supported careful language use

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Semantic waves

Jane Waite

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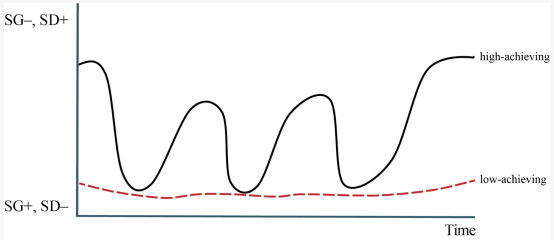
Analysing social interactions



20 mins

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Feedback literacy

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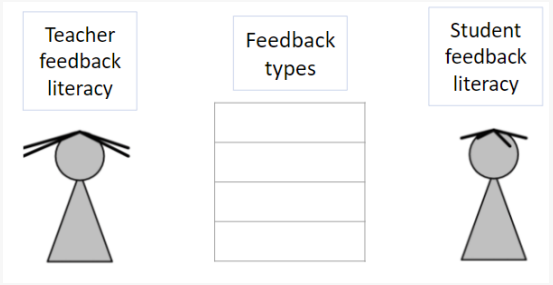
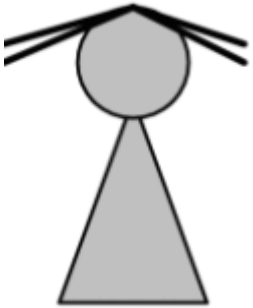


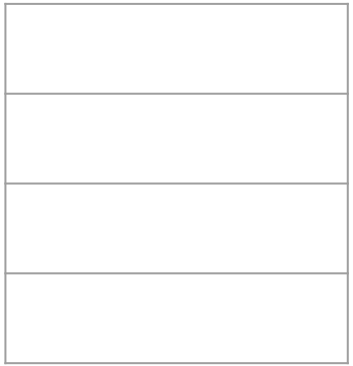
Feedback literacy

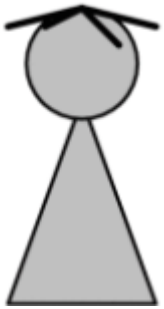
Teacher feedback literacy

Feedback types

Student feedback literacy







Providing feedback (an explanation) is a social interaction.

(inspired by [p2] Rohlfing *et al*., 2020)

Feedback types

Feedback type	Educator role	Student role
Telling	unidirectional transmission of ‘correct’ information	passive
Guiding	point in the right direction	active as applies knowledge
Developing understanding	targeted teaching	active as constructs or adjusts knowledge
Opening up	presenting new perspectives	active as interprets and evaluates new knowledge

(McLean, Bond & Nicholson, 2015)

Student feedback literacy

Student feedback literacy requires students to

- appreciate feedback processes
- make judgements
- take action
- manage affect

(Carless, 2018)

Teacher feedback literacy

Teacher feedback literacy requires the teacher to

- design the feedback within the learning context
- take account of the relational aspects
- be pragmatic about feedback

(Carless & Winstone, 2023)

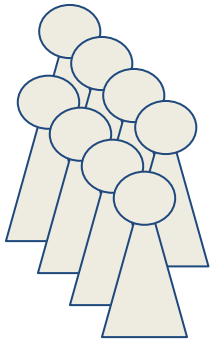
Teacher feedback literacy

Teacher feedback literacy requires the teacher to

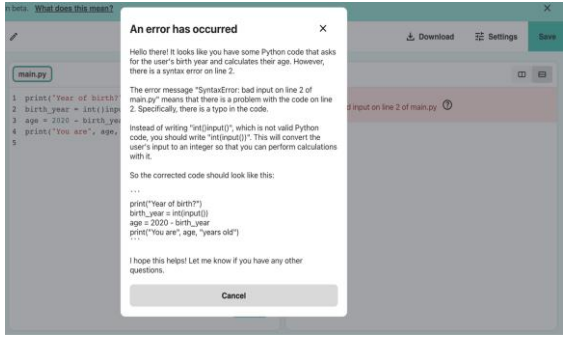
- design the feedback within the learning context
- take account of the relational aspects
- be pragmatic about feedback

(Carless & Winstone, 2023)

Feedback literacy study



8 expert secondary computing teachers



Explored LLM explanations of program error messages from an augmented IDE (Python beginner programming)

Table 3: Correlation of feedback theories to themes

Feedback theory	Themes (Table 1)
Feedback types [24]	
Telling	1, 5, 7
Guiding	1, 3, 4, 5, 7
Developing understanding	2, 3, 4, 5, 8, 9
Opening up new perspectives	8, 9
Student feedback literacy [7]	
Appreciating feedback process	1, 10
Making judgements	1, 2, 3, 5, 7, 8, 9, 10,11
Taking action	5, 7, 8, 9, 10, 11
Managing affect	6, 8, 10, 11, 12
Teacher feedback literacy [8]	
Design dimension	13,14
Relational dimension	15
Pragmatic dimension	15

(Cucuiat & Waite, 2024)

Feedback literacy findings

Feedback types

Educators preferred the LLM explanations to be **guiding** and **developing understanding**, rather than **telling**;

Student feedback literacy

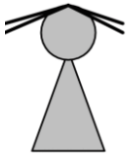
Educators talked about how LLM explanations helped or hindered students to **make judgements** and **action the feedback** e.g. if the output was wrong, how the output was formatted, what vocabulary and concepts were included**;**

Teacher feedback literacy

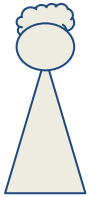
Educators discussed the need for professional development to **design feedback** and issues of reduced opportunities to work with students to understand their progress (**relations**).

(Cucuiat & Waite, 2024)

What about the ecosystem of an hybrid interaction system explanation?



Teacher feedback literacy

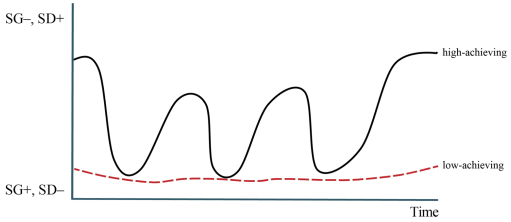


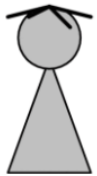
System designer feedback literacy

Copilot ChatGPT etc

"AI agent feedback literacy"

Feedback types





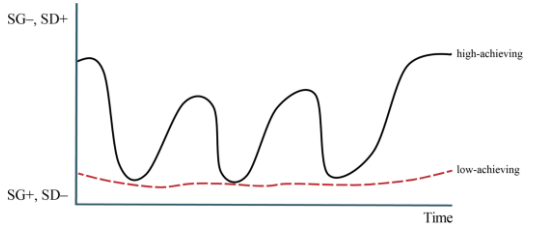
Student feedback literacy

(inspired by [p2] Rohlfing *et al*., 2020)

Suggestions to explore as research…

1. Case study – Analyse your own teaching using Semantic Profiling.

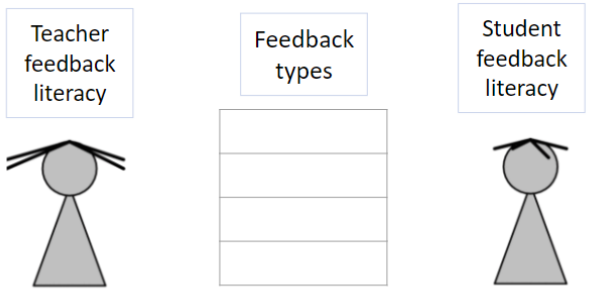
2. Teach your students about Semantic Profiling to spot and construct good (wavy) explanations
   a. For non-AI interactions
   b. For AI interactions



Suggestions to explore as research…

1. Case study - review your own teaching context and what feedback types are used.

2. Teach your students about feedback literacy and how to use
   a. For non-AI interactions
   b. For AI interactions



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Thanks for listening, we look forward to your questions!

Jane Waite

Contact us at jane.waite@raspberrypi.org
Follow our work at: computingeducationresearch.org

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Finding out more

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For Semantics

- For a taster, read the quick read
- Read this blog from Professor Paul Curzon
- Find out more on LCT, Semantics and profiling at the LCT website.
- Consider using LCT in your research.

Join the LCT community - a brilliant group of educators and researchers!

For Feedback Literacy

- Read our paper Feedback Literacy: Holistic Analysis of Secondary Educators' Views… (ITICSE 24) not quite out yet.
- Read some of the feedback literacy references (next slide)

References

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