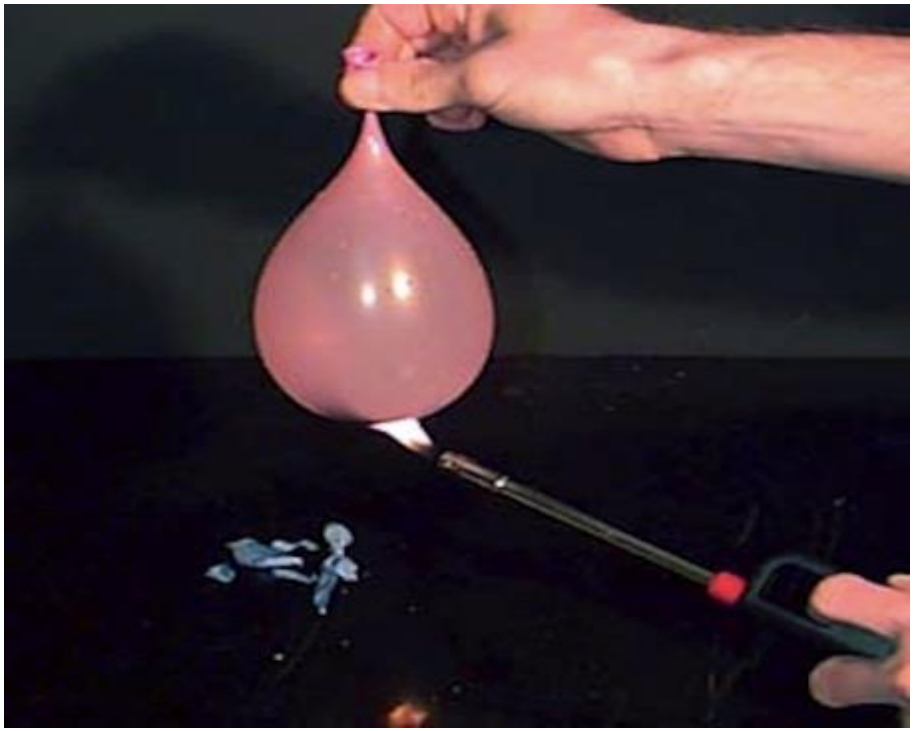
Thinking Frames: Encouraging conceptual change and improved written explanations through student generated representations



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The Problem

- Conceptual change is difficult
- Students tend to write simplistic answers to higher order questions
- Students often have low feelings of self-efficacy in Science

What the literature says

- Many students say that they are not good at Science
- Students often lose interest in Science after Year 7
- Many students see Science as facts to be memorised rather than understanding the underlying models which are constantly being refined.
- Understanding students' alternative conceptions enables teachers to address these conceptions, leading to conceptual change.
- Students' pre-scientific conceptions are very persistent.

What does the literature say

- Use of multiple representations have been shown to:
  - Scaffold acquisition of knowledge and encourage deeper conceptual understanding
  - Encourage development of internal representations
  - Develop fluency in retrieving and amending internal representations
- Classroom discussions and argumentation – persuading others - helps students construct explanations.
- Self-evaluation is a powerful tool in improving student writing

The Thinking Frame Approach (TFA)

- Students placed in small, mixed-ability groups of 4-5.
- P.O.E. model
- Students produce an explanation for observations.
- Students present ideas to the class
- The teacher encourages use of the scientific model
- The Thinking Frames question is introduced and students draw and write explanations.
- Students use the ‘Levels Mountain’ to evaluate their paragraph.
- Feedback to students.

Topics addressed with TFA

- Grade 8
  - Cells and body systems (5)
  - Energy, transformation and conservation (4)*
  - Matter and Change*/Particle nature of matter (10)*
- Grade 9
  - Chemical bonding/ atomic structure/radioactivity (4)
  - The nervous and endocrine systems (3)
  - Thermal physics (6)*
  - Electricity (3)*
- Grade 10
  - Newton's Laws (7)*
  - Genetics (7)*
  - Natural Selection/Evolution (2)*

Grade 8 pre/post test results

Topic (Group)	Pre-test Score Mean (SD)	Post-test Score Mean (SD)	Cohen Effect size
Energy (8Ein 2015)	44 (14)	59 (18)	**0.94**
Energy (8C in 2015)		42 (17)	
Matter and Change (8E in 2014)	52.8 (10.7)	69.0 (10.5)	**1.53**
Matter and Change (8E in 2015)	59.3 (12.3)	72.2 (13.4)	**1.00**
Particle Model of Matter (8E in 2014)	46.8 (16.8)	66.1 (14.8)	**1.21**
Particle Model of Matter (8E in 2015)	48.2 (17.5)	62.0 (11.6)	**0.93**
Particle Model of Matter (8C in 2015)		47 (16)	

Grade 9 pre/post test results

Topic (Group)	Pre-test Score Mean (SD)	Post-test Score Mean (SD)	Cohen Effect size
Thermal Physics (9E in 2014)	25.3 (10.5)	45.7 (15.1)	**1.57**
Thermal Physics (9C in 2014)		26.4 (7.1)	
Thermal Physics (9E in 2015)	28.8 (10.7)	55.1 (15.0)	**2.04**
Thermal Physics (9C in 2015)	32.9 (10.2)	30.2 (10.6)	**-0.26**
Electrical Current (9E in 2014)	27 (22)	50 (31)	**0.88**
Electrical Current (9E in 2015)	17 (16)	59 (26)	**1.98**
Electrical Current (9C in 2015)	20 (18)	47 (26)	**1.24**

Grade 10 pre/post test results

Topic (Group)	Pre-test Score Mean (SD)	Post-test Score Mean (SD)	Cohen Effect size
Newton's Laws (10E in 2015)	26.3 (10.2)	41.5 (14.5)	**1.21**
Newton's Laws (10C in 2015)	24.3 (10.4)	25.3 (8.5)	**0.11**
Genetics (10E in 2015)	21 (17)	55 (19)	**1.87**
Genetics (10C in 2015)	12 (13)	40 (16)	**1.93**
Natural Selection (10E in 2015)	43.3 (14.5)	60.2 (18.5)	**1.02**
Natural Selection (10C in 2015)	38.6 (12.9)	32.7 (11.5)	**-0.48**

Example Lesson – Thermal Energy

Student written explanations

- *"A cup without water will burn because it's reached its ignition point. However, due to thermal equilibrium, a cup with water will transfer energy from the cup to the water . Water's boiling point is 100^{o}C, so until the water is completely vaporised , the cup will continue transferring heat to the water. Due to latent heat of vaporisation, the energy will go to separating the water particles and the temperature will stay at 100^{o}C. Assuming the cup's ignition point is above 100^{o}C it will not ignite until the water has fully vaporised."* [5]

What do students say about TFA?

- *Willa: At the beginning of the year – [confidence in understanding new concepts was] a 2 out of 10 because I knew a limited amount of stuff about concepts, but learning new concepts was really hard because it wasn't really working for me. And now it is like a 10 because I know a lot of new stuff and it is easier for me to learn new concepts with the TF.*

- Cathryn: *I love them. I just think "what are you on about. They help!" We do the keywords and that really helps because then I know what kind of language I should be using in my explanation. The pictures help because visual descriptions of something really help me. And then when you have to the dot points of the explanation that also helps because that's the basis [of the paragraph]. Which is good and makes it easier to write the explanation.*

Attitude to science

- *"I used to think science was a bit boring but now I'm interested in it."*
- *" Other things however sometimes I come and I'm like why do I need to know this? I'm never going to become a scientist or anything. But after I've done it I feel it's really interesting to know, and it'll, one day if someone asks me about it I can be like I know this. And then I can tell everyone."*
- *I am seriously considering it [studying Science]. I am thinking about being a science teacher or some kind of teacher, but, cause I have really enjoyed and I have found that I am alright at explaining concepts to other people and it has been fairly enjoyable and I have thought "I can do that".*

Observations of colleagues

- TA observations (3TAs):
  - Engagement and enthusiasm:
    - *I do remember a pretty good buzz in most of those lessons. And that was one of the reasons that I enjoyed them (M).*
  - Increased confidence to ask questions
    - *I did see a few of the below average kids more confident to speak out than normal because they understood the work a bit better than normal (M).*
  - Supports constructivist teaching:
    - *It is really student-centred. Because you are really forcing them to get the ideas themselves*
  - Greater engagement in higher order thinking:
    - *It forces them to think. It forced them to come up with a coherent picture of what was going on and if they got it wrong, it was obvious for them that they were getting it wrong because it didn't answer the question.*

Students with special needs benefitted

- Structure and routine supported student learning
  - *So its great for advanced kids but particularly helpful for the less advanced because it is a step by step guide that will get them through the thinking process and get them there at the end.*
- Small groups supported student learning:
- Supported contributions to discussions:
  - *There were cues in the framework to help find points to talk about (R).*
- Reduced anxiety:
  - *C was no longer super anxious. I found with the TF he always seemed to be very calm, always confident with what he was doing and I often questioned why I was there during those lessons because he didn't need my help. He was quite happy just doing it himself and just getting it done (M).*

Acting Principal's Perspective

- *There has been a notable lift in student interest and achievement in Science since the implementation of Thinking Frames in your classes. In my time as Acting Principal, students and parents reported increased student confidence in subject matter and a willingness to undertake Science subjects in Years 11 & 12 where previously they had decided not take take Science. Notably, increasing numbers of young women express the desire to study Science and pursue a career in a Science field. The application of Thinking Frames approaches to AST preparation saw a lift in the median ATAR score for 2015 results. Data from UNSW Science Competition revealed improved learning outcomes for students who had previously taken those tests. I would say there has also been a skill transfer to other subject areas - those students now writing well in Science are writing with more precision in English and humanities subjects.*

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Thinking Frame

Thinking Skills

Name(s) _____ Date _____

Explain WHY _____

BRAINSTORM

Key ideas(s) to use in the explanation: ENERGY/FORCES/PARTICLES/CELLS

KEY WORDS

SEE / VISUALISE

I/We think that these ideas are at level _____
Because.....
_____

_____

adapted from www.thinkingframe.com

Thinking Frame

Thinking Skills

THINK / SEQUENCE

What happens	→	Why
•		
•		
•		
•		
•		

PARAGRAPH

Write your answer to the problem as fully as you can. *(HINT Use cause and effect words such as consequently, because, whenever, depending upon, eventually, since, until etc)*

_____

_____

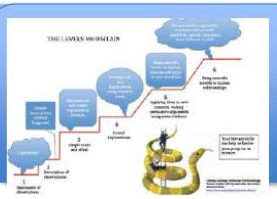
_____

_____

_____

_____

_____



I/We think that these ideas are at level _____
Because.....

_____

_____

adapted from www.thinkingframe.com

The Levels Mountain

- Level 1, simple description or inaccurate explanation
- Level 2, description of what happens without explanation or limited explanation
- Level 3, simple relationship between cause and effect
- Level 4, extensive explanation of cause and effect accurately using scientific language
- Level 5, successful application of concepts learned in a less familiar situation with detailed explanation of cause and effect using scientific terminology.