The ‘Sand on a sill’ international collaborative research project

The ‘sand on a sill’ research project is planned to:

- Teach about the rock cycle – in particular that rock cycle processes are not just abstract things that happen somewhere else, but surface rock cycle processes act everywhere most of the time
- Provide an assessment tool for assessing rock cycle teaching
- Be applicable to any students of any age anywhere on Earth
- Test the efficacy of teaching through a thought experiment based on reality
- Test the efficacy of discussion-based collaborative learning
- Promote the use of thought experiments in teaching
- encourage interactive and pupil-centred teaching
- Provide the opportunity for any Earth science teacher anywhere to become engaged in some small scale action research
- Allow teachers across the world to feed their own data into a growing bank of data, and see how their feedback affects the overall result
- Provide a research-based rationale for this form of teaching

The project derived from a discussion on research into Earth science education at the International Geoscience Education Organisation conference, GeoSciEd VII, in Hyderabad, India in 2014. It is based on the ‘Sand on a sill’ Earthlearningidea which was written and published as a result of this discussion.

Research question

How effective is the evaluation of thought experiments based on reality which involve student discussion (such as the ‘Sand on a sill’ activity) in showing progress in learning?

Theories:

- Older pupils perform the task better than younger pupils
- Pupils that have been taught about the rock cycle perform the task better than those who have not
- Pupils who have been taught about the rock cycle refer to the rock cycle and use rock cycle terms; those who have not, do not.
- Older pupils make more links to parts of the Earth system than younger pupils (e.g. lithosphere, atmosphere, hydrosphere, biosphere)

Research background

The CASE intervention

The work of Adey, Shayer and Yates (2001) published in their ‘Cognitive acceleration through Science Education’ (CASE) programme devised to develop the thinking skills of pupils through science contexts, is relevant, since it is based on five main elements (called ‘pillars of CASE wisdom’). The table below shows the relevance of these elements to the ‘Sand on a sill’ activity:

<table>
<tr><th>The ‘five pillars of CASE wisdom’</th><th>Description of each pillar</th><th>Comment on its relevance to the ‘Sand on a sill’ activity</th></tr>
<tr><td>Concrete preparation</td><td>the terms of the problem need to be established</td><td>Relevant to this activity</td></tr>
<tr><td>Construction</td><td>students must construct their own reasoning processes</td><td>Relevant to this activity</td></tr>
<tr><td>Cognitive conflict</td><td>thinking develops in response to cognitive challenge</td><td>Relevant to this activity</td></tr>
<tr><td>Metacognition</td><td>reflection on the process of problem solving is essential</td><td>May be relevant to this activity, depending on how the discussion develops</td></tr>
<tr><td>Bridging</td><td>reasoning patterns developed … must be bridged to other contexts</td><td rowspan="2">The rock cycle thinking here might be linked in discussion to other Earth cycles and to Earth Systems Science</td></tr>
<tr><td colspan="2">Adapted from: Adey, P. (1999): 6, Fig. 1</td></tr>
</table>

	thinking

Bloom's taxonomy
Discussion has the potential to develop higher level thinking skills, as outlined in Bloom's taxonomy, in the table.

Bloom's taxonomy		Modified Bloom's taxonomy	**Comment on its relevance to the 'Sand on a sill' activity**
Original taxonomy from Bloom, 1956		Andeerson & Krathwohl's modification of Bloom's work (2001)	
Increasing contextualisatio	Evaluation	Creating	May be relevant – depending on level of discussion
	Synthesis	Evaluating	
	Analysis	Analysing	
	Application	Applying	Relevant
	Comprehension	Understanding	
	Knowledge	Remembering	

Vygotsky's social interaction theories
The discussion in the 'Sand on a sill' activity has the potential for more able pupils to act as 'More knowledgeable others' to support the ideas and learning of less able pupils, as in Vygotsky's social development theory (1978). In Vygotsky's theories, social interaction, as in the 'sand on a sill' discussion, have a central role in cognitive development.

Piaget's formal operational thinking stage of learning
Although the 'Sand on a sill' discussion activity is rooted in reality (i.e. the real sand grain on a real window sill) developing a sand grain 'story' involves the abstract thinking skills described by Piaget as 'formal operational thinking' skills (Inhelder & Piaget, 1958). These are described by Day (1981:45) as 'the formal operational individual's thought can be described as *hypothetical-deductive* in nature. The formal thinker is able to construct hypotheses to account for particular phenomena, deduce from these hypotheses that certain events should occur, and test the hypotheses by finding out if the events do occur.'

Meta-analyses of small group discussions in science education
The Science Review Group (2004: 61) study found that: 'The use of small-group discussions supported by a specific programme fostering collaborative reasoning (including evaluating and strengthening of knowledge claims) improved students' metacognitive knowledge of collaborative reasoning (including their knowledge of reasoning about evidence) significantly more than for students not following the special programme.'

Hogarth et al's analysis (2005: 9) found: 'a successful stimulus for students working in small groups to enhance their understanding of evidence has two elements. One requires students to generate their individual prediction, model or hypothesis which they then debate in their small group (internally driven conflict or debate). The second element requires them to test, compare, revise or develop that jointly with further data provided (externally driven conflict or debate).'

Bennett et al's analysis (2009:46) found: 'the reviews do indicate that there could be benefits arising from this, as small-group discussion work can provide an appropriate vehicle for assisting in the development of students' understanding of science ideas.'

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