Parallel 3 & 4

USING ENGLISH IN THE TEACHING OF SCIENCE

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ABSTRACT

This double session presentation consists of a workshop followed by a discussion of what the workshop has revealed.

These two sessions reflect the well-established argument that cognitive learning is most effective when it is supported by a constructive emotional environment.

In Part 1, the workshop participants will experience tasks that show how, the threatening activity of learning subject matter in an unfamiliar language can be shaped, so that learners can be supported in taking risks and the learning of both English language and scientific concepts can be enhanced.

In Part 2, in the subsequent reflections we will explore how the organization and sequencing of the activities in the workshop allowed for participation by learners with different levels of English proficiency and scientific knowledge. We will also explore how to progressively move the learners toward more extended and independent uses of spoken and written English and provide contexts in which learners can deepen their understanding of scientific concepts. We argue that this approach provides a means to avoid some of the cultural imperialism involved in learning through English.

Part 1, Workshop:

The activities in this session demonstrate ways in which students from diverse linguistic backgrounds with different levels of scientific and mathematical understanding can be integrated in a single activity that will induct them into new ways of knowing and help them to express these ways of knowing in a new language. We will focus on a single activity (making 'slime') and conduct the activity in English. We have chosen 'slime' because it enables us to demonstrate some of the key claims about the organization and outcomes of such activities. 'Slime' is able to be physically manipulated by scientifically inexperienced learners, reveals a process of change, is capable of use with learners of varied ages and requires little sophisticated technology while capable of revealing sophisticated scientific and mathematical concepts. Through the making and manipulation of 'slime' we explore ways in which the learning of subject matter in a second language and the learning of the language itself can be integrated.

The approach adopted reflects the insights of content-based language teaching (Adamson, 1993; Mohan, 1986) and the meaning-focussed implications of first and second language acquisition theory (Lantolf, 2000). The approach addresses the needs of science and mathematics teachers in Malaysia to both further develop their English and teach mathematics and science in ways that enable their students to learn the concepts of the subjects and to gain control of English (Gaudart, 1996; Wong & James, 2000).

The language-based skills that participants will develop in the context of science and mathematics at these workshops, which will be useful in assisting teachers in schools are:

> questioning skills to elicit students' understanding
> listening and observation skills to monitor teachers' areas of weaknesses in language use and to provide appropriate feedback and assistance
> designing lesson plans for content delivery
> explanation skills, descriptive and diagrammatic
> assessment (both formative and summative) of students' conceptual understanding
> conducting group work and discourse
> preparation of teaching aids such as worksheets, and developing curriculum materials
> writing test questions

> practical work and report writing

However, these language-based skills have both (1) a pedagogic dimension (they are motivated by the requirements of good teaching) and (2) are integrated with the need to ensure that the subject matter that frames them and gives them meaning is learned at the same time. We need, therefore, to consider how to frame the language activities themselves in the context of an appropriate methodology.

The approach to teaching that we have adopted reflects the following key principles:

1) learning any content is first and foremost learning how to,make meaning (e.g. to distinguish what is 'agreed with' or 'questionable' what is 'new' or 'not said')
2) learning that content also requires engagement with that content (usually mediated by another though the best means of mediation are open to multiple cultural interpretations);
3) gaining control of the content involves not only reflecting on the content, but also (partly as an act of reflection) attempting to express the content in a variety of ways beginning with more concrete and flexible means;
4) all learning involves extending from the known to the unknown and in this process errors are frequently if not inevitably made - good teaching involves using the thinking that leads to the errors to enable the learner to move beyond the errors to more productive insights and forms of expression;
5) the learners' experiences will shape their learning and therefore need to find a place in the teaching process and to be positively acknowledged by the teacher;
6) good teaching involves the positive acknowledgement and incorporation of learner effort as well as constructive and directed feedback.

In the workshop activities we will explore the following interrelationships between subject matter learning and language learning:

Task	Language
Establishing what is already known/imagined	**Teacher:** (oral): forming open-ended questions; forming closed questions; acknowledging or clarifying student contributions; prompting more contributions; making comparisons between answers; (written) spelling; writing notes **Students:** (oral): making (tentative/hypothetical) statements; asking clarification questions; confirming clarification requests; (written): making notes if working in pairs
Setting up/outlining task	**Teacher:** (oral): issuing instructions - choice of declarative [1 want you to do] or imperative [do] mode; (seeking confirmation?); connectives [temporal sequence]; (written): list format **Students:** (oral) clarification of meaning (what's that?)
Making slime	**Teacher:** (oral): confirmation requests; corrective feedback and instruction modifications; closed and open-ended questions **Students:** (oral): descriptions of ongoing processes; descriptions of previous and future actions; descriptions of outcomes of actions; open questions (some speculative 'what would happen if ..T); praise; encouragement; (written): sequenced notes describing processes and outcomes
Reporting experience	**Teacher:** (oral): eliciting sequenced descriptions; praising; soliciting comment; elicitation commands ('tell me more 'l' go on')
	Students: (oral): producing sequenced reports; (written): reading notes
Reflecting on experience	**Teacher**: (oral): opening questions; discussion guidance; (written): formal descriptions of processes **Students:** (oral): speculative explanations (1 think'/'it could be that..') (written): formal register report

Part 2, Discussion:

The learning theory of constructivism has been highly influential in science education over the last two decades (Phillips, 2000). The underlying principle of constructivism is that the learner is an active participant in the construction of knowledge and that existing knowledge and a socially interactive environment (Vygotsky, 1962) are factors that affect this construction of knowledge.

Students can engage with this topic/activity at a number of different levels. We exemplify these levels briefly below:

Expectations at primary years (prep, 1,2,3,4), middle years (5,6,7,8,9) and upper secondary years (10, 11, 12)

Lower primary students would make the slime and be encouraged to

- explore the making of and playing with the slime using their senses
- develop their communicative skills by orally describing what they have done (e.g. pretend that they have to tell a parent about it after school) - in this context they do not need to use scientific terms e.g. PVA (polyvinyl acetate) or borax. However terms like liquid (white, sticky liquid for PVA and liquid that looks like water (borax) would be encouraged.

Explanations to middle years students should make use of simple language in explaining the science behind slime, but can make more use of both scientific concepts and (concrete) scientific terminology. If you can see the particles making up PVA (polyvinyl acetate) glue, you will find that they are joined together to form string/ strands. These strands are free to move around and slide over each other like cooked spaghetti. When you stir in the borax, it binds the *Strings together, like rungs in a ladder. This is called cross-linking and water is trapped in between the strings of PVA glue. The cross-linking results in a network of glue strands and they cannot move and flow as easily as before. The bonds (which can be labelled in a number of different ways e.g. rungs, bridges, bindings, cross linking) formed between strings are quite flexible and can stretch. This issue can be explored both as a result of natural experimentation 'what happens if ... ?' and as a result of teacher demonstration. The effect is what you observe when you let the slime flow freely out of your hand - the slime will stretch all the way down. But if you stretch the cross-linkages between the PVA strings too much, the linkages break and you have two bits of slime. But you can 'stick' them back together again. The water trapped in between the strings helps to give the slime its soft and mouldable nature. Students can be challenged to both describe what they see happening, speculate as to why it has happened, be encouraged to explore alternative explanations and to build small arguments

about competing explanations. The teacher can use these opportunities to present the language of science in terms of logical argument building, appeals to evidence and hypothesis testing or generalisation

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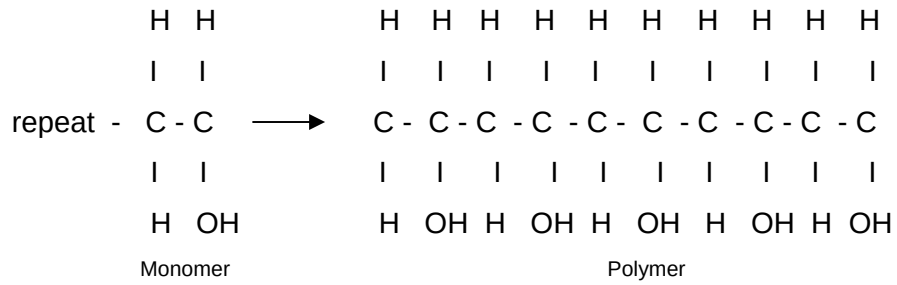
Using slime to teach about polymers at the higher levels (years 11 and 12)

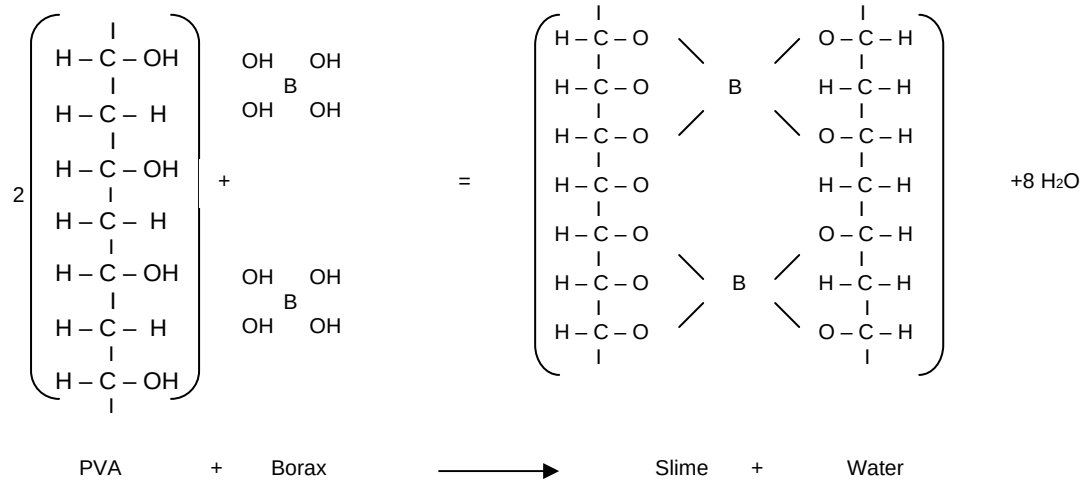
At the higher levels, the chemistry is usually explained in terms of polyvinyl alcohol (instead of polyvinyl acetate) as higher level students should be able to get access to polyvinyl alcohol. It makes better slime as it gives a less rubbery slime and because polyvinyl alcohol is transparent (unlike the PVA glue which is white) the colour shows up better.

Students at these levels talk about monomers (single units/molecules of whatever chemical, this case it would be vinyl alcohol) joining together to form long chains of the polymer polyvinyl alcohol. This joining together of many units of monomers is called polymerization. Polymerisation is a very important chemical process which produces many products that we use e.g. nylon, dacron, synthetic rubber, paint, different types of plastics, chewing gum and starch. The joining of monomers can be achieved by the processes of addition polymerization or condensation polymerization.

The chemical structure of the monomer vinyl alcohol and the polymer form, poly(vinyl alcohol) are shown below:



The chemistry by which slime is produced involves the borate ion cross-linking with the polyvinyl alcohol. Borax hydrolyzes in water to form a borate ion, B(O11)4-. This tetrahedral borate ion "crosslinks" with the poly (vinyl alcohol) to produce slime and water.



Slime is a non-Newtonian substance which when subjected to stress, its behaviour changes. With a larger force applied to it like stirring it quickly, it becomes hard and acts like a solid but when you apply a smaller force, like stirring slowly, it becomes more fluid and acts like a liquid.

The different Science and Mathematics learning approaches that we have demonstrated include:

Cognitive. Cognitive techniques provide opportunities for students to interact with the materials being learnt and require the students to manipulate the material mentally or physically. The hands-on approach would be one of the most useful strategy to teach Science and Mathematics. The approach promotes development of conceptual understanding and critical thinking skills as well as encourages discourse in the English language. Hands-on does not mean merely the manipulation of objects. It is an approach where students are actively interacting with the materials to be learnt and constructing meaning and understanding through these interactions. The hands-on approach lends itself very well to the learning theory of *constructivism,* a theory widely acclaimed in Science and Mathematics education as an effective way of learning concepts in these fields. The hands-on approach is very student-centred and strategies employing hands-on activities include experiments, interpretive discussions, role play, open investigations and problem solving. In considering these hands-on approaches to teaching Science and Mathematics, the class size, availability of resources and the content that needs to be delivered in the Malaysian context will be taken into account.

Social-affective. This approach involves interactions with other members of the class to assist with the learning. Social-affective strategies include working cooperatively in small groups and questioning for clarification.

Metacognitive. This approach develops higher thinking order skills in planning for learning, monitoring the learning while it is taking place and reflecting on and evaluating the learning. Reading selectively and self-evaluation are metacognitive strategies.

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