ELIS
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OF SINGAPORE

SUBJECT LITERACY
INQUIRY DIGEST

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PRINCIPAL'S MESSAGE

Since ELIS was established in 2011, it has continuously worked to develop new learning experiences for teachers, opportunities to interact with experts, and resources to use in the classroom, such as the 'Let's Talk!' card game.

Another strand of the ELIS support model is to work with teachers on inquiring into their own practices. It is with great pleasure that I can introduce the inaugural edition of the Subject Literacy Inquiry Digest. This digest showcases classroom inquiries carried out with the Subject Literacy Team into how learning in school subjects can be enriched through the lens of subject literacy. The role of inquiry is essential in uncovering what language and literacy support works in classrooms, and also what does not.

Please enjoy looking into these inquiries into improving learner outcomes through supporting learner language. I hope you too can take away something which will inspire you to collaborate with the Subject Literacy Team or carry out inquiries with a group of teachers in your school.

Mr Jeffrey Low

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Jonathon Adams
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The editors would like to thank Shalini Damodaran and Susan Gwee for reviewing the articles.

FOREWORD

If, as many educators believe, a teaching strategy works differently in different contexts for different students, then there is no 'one-size-fits-all' solution to the routine problems of learning that teachers encounter almost on a daily basis. Such problems may be framed as questions, such as: How can I help the students understand this concept? Will this question lead to discussion or blank looks? How can I help my students to construct coherent and accurate explanations? How can I help my students communicate their thinking more effectively?

Teacher inquiry is a professional and powerful way for teachers to answer questions like these in class, in the lesson, and with colleagues, using their own resources and sometimes drawing on the expertise of others. In the words of Helen Timperley and her colleagues, such inquiry is:

> *A process in which those involved investigate what is working well for student learning and achievement and why, so it can be continued, and what is not working well and why, so it can be changed. (Timperley, et al, 2007)*

ELIS works with subject teachers to assist them with developing scaffolding strategies for the literacy aspects of learning their subjects. This is only the first step in a journey to explore their practice.

Teachers trial new teaching strategies, adding to their existing repertoires for teaching Mathematics, Science and the Humanities. They find ways of collecting evidence of student learning as they do this, and use this evidence to make decisions about how effective these changes to their practice have been.

In collaborative school-based inquiry studies, such as those with North Vista Primary School and Junyuan Secondary School reported here, members of ELIS's Subject Literacy Team guide teachers with this exploration. They help teachers to frame inquiry questions that will allow them to consider what kinds of evidence they will need to collect of their students' learning in order to know whether the students have learned more (or less) than using their previous forms of classroom practice.

As part of this ongoing work, ELIS also follows a cycle of inquiry and knowledge building (Timperley et al, 2007), so that our team considers what is working well for teacher learning and achievement, and what is not. The study with St. Andrew's Junior School reported here is one example of our ongoing inquiry into methods of professional learning.

The entire process of inquiry is guided by the Teacher Inquiry and Knowledge Building Cycle (Timperley, 2008). The stages of the inquiry are:

1. Identifying the needs of students
2. Identifying what is needed to meet students' needs
3. Reflecting, learning and planning new learning experiences
4. Engaging students in new learning experiences
5. Finding out the impact of teachers' changed actions on students' learning through lesson observations and teacher reflections

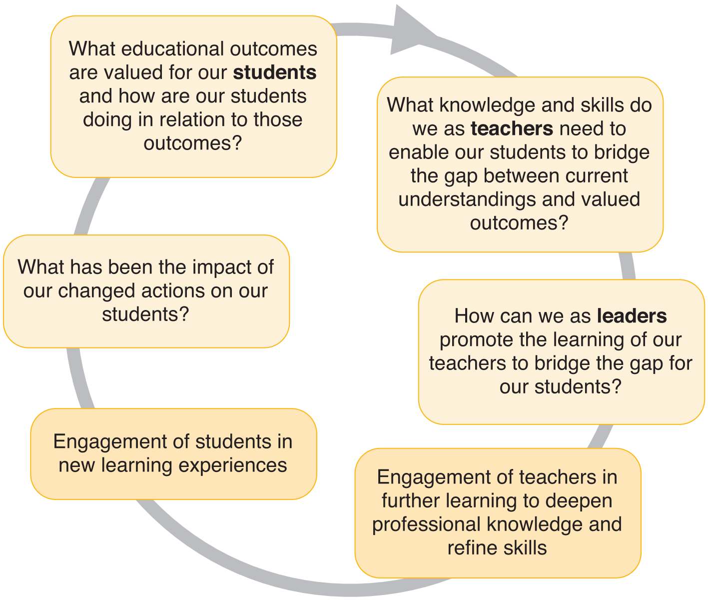

Figure 1. Teacher inquiry and knowledge-building cycle to promote valued student outcomes. (Reprinted from *Teacher professional learning and development* (pp. 26-7), by H. Timperley, 2008, Brussels, Belgium: International Bureau of Education. Copyright 2008 by UNESCO International Bureau of Education. Reprinted with permission.)

Together, students, teachers and professional developers build communities of practice that strive to improve and move forward. This involves taking small steps and remembering the path taken, so that they can discern the path ahead.

Dr Paul G. Doyle

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Scaffolding Written Explanations in Primary Science

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INQUIRY FOCUS

Two Science teachers at North Vista Primary School identified difficulties with writing clearly structured explanations that their Primary 3 students experienced. The teachers redesigned worksheets to address students' subject literacy needs by developing word banks, gap-fill activities and model answers.

BACKGROUND

Science is a literate activity, with a significant amount of time spent on reading and writing reports, discussions and exploring research methods (Shanahan, 2012, p.158). When learning Science, students need to understand the texts used in class, such as textbooks and worksheets, in order to make sense of the physical experiment being undertaken (Shanahan, 2012, p.157). Explanations are 'a key feature of inquiry' in Science, which are used to articulate meanings, persuade and 'make sense of the data following either experimentation or analysis of data gathered from someone else's experiment or observations' (Spiegel, Bintz, Taylor, Lands, & Jordan, 2010, p. 106).

Recent research in subject specific literacy support has identified a range of scaffolding strategies to support student learning. For example, Chadwick (2012, pp. 12-13) offers a variety of question and answer frames that can be used as language scaffolds. Teachers can also provide scaffolding to support students in explaining their thinking (Gibbons, 2009, p. 73) by deconstructing model answers and using gap-fill activities.

PROCEDURE

The two teachers decided to carry out an inquiry into their teaching, after they noticed that their students' written explanations often lacked clarity and depth, with one word answers being common. The teachers decided to address this by providing scaffolding for explanations in the class worksheets. They also wanted to encourage students to use key scientific terms from the Singapore Primary Science Syllabus (Curriculum Planning & Development Division, 2013) in their explanations.

The teachers first examined student explanations and compared them to expected model answers. Following this, the teachers worked with the ELIS consultants to design language scaffolding that would enable students to move from writing the short, single word answers they commonly produced to writing structured explanations in complete sentences.

The greatest difficulty Teacher 1's students faced was that they saw Science concepts in isolation. For example, students did not seem to be able to associate the property 'durable' with materials such as metal.

Subsequently, Teacher 1 decided to scaffold worksheets by adding word banks and gap-fill activities as a way of getting students to focus on scientific terms that were required in the explanations.

Figure 1 shows an example of a worksheet with this additional scaffolding. Using an interactive whiteboard, Teacher 1 demonstrated how students could select terms from the word bank to complete the gap fill task.

Teacher 2 realised that students needed more explicit guidance in the writing of explanations because they frequently sought help during writing activities. The students' written explanations were often very short and lacked a coherent structure; in some cases, essential information was omitted. As a step towards guiding students to write explanations independently, Teacher 2 decided to incorporate model answers in the worksheets. Prior to the writing, the teacher guided students through the model answers by picking out key scientific terms related to the properties of materials, such as 'transparent' and 'waterproof'. Following this, Teacher 2 demonstrated how to structure an explanation using the example model answer. Figure 2 shows the model answer provided by Teacher 2 in the worksheet. In the part titled 'My explanation', the scientific terms are in bold, and the explanation is given as five complete sentences. As scaffolding is temporary, the language support included in the worksheet was not planned to feature in all the following worksheets, but to be gradually removed over time as the students developed the skill to write explanations more independently.

In these ways, the two teachers adapted the worksheets they were using in their Science lessons to meet their students' literacy needs.

After the lessons, the worksheets were collected and the students' written responses were analysed to evaluate the effectiveness of the strategy. In discussion with ELIS consultants, the teachers reflected on the effectiveness of the language scaffolding activities in improving students' written explanations in Science.

3. What do you notice about the objects that are attracted/ not attracted to the magnet?

Some metals like iron and __________ are attracted to the magnet.

Some metals such as __________ and __________ are not attracted to the magnet.

Non-metals such as __________ and __________ are also not attracted to the magnet.

steel	glass	plastic	aluminium	copper

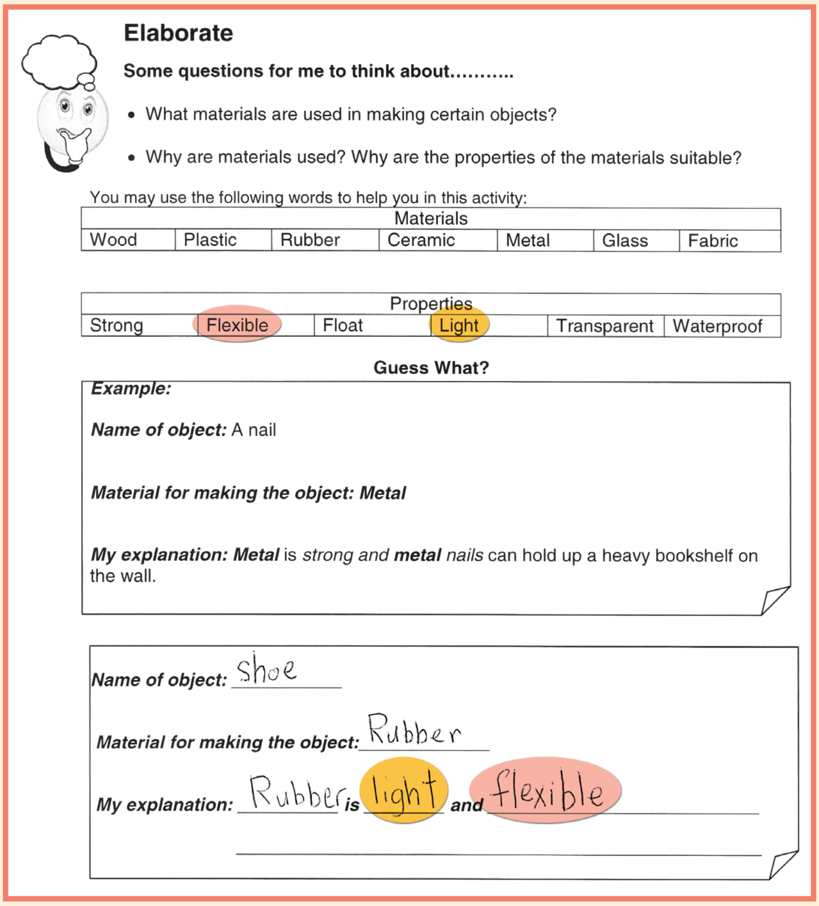
Figure 1. Word banks and gap-fill activities
(North Vista Primary Science Department, 2014, p. 11).

Name of object:
Window panes

Material for making the object:
Glass

My explanation:
Glass is **transparent**. *It allows most light to pass through.* Glass is also **waterproof**. *It does not absorb water.* Therefore, glass is used to make window panes.

Figure 2. Example answer for students
(North Vista Primary Science Department, 2014, p. 11).


Elaborate

Some questions for me to think about...........

- What materials are used in making certain objects?
- Why are materials used? Why are the properties of the materials suitable?

You may use the following words to help you in this activity:

Materials						
Wood	Plastic	Rubber	Ceramic	Metal	Glass	Fabric

Properties					
Strong	Flexible	Float	Light	Transparent	Waterproof

Guess What?

Example:

Name of object: A nail

Material for making the object: Metal

My explanation: Metal is *strong and* ***metal*** *nails* can hold up a heavy bookshelf on the wall.

Name of object: Shoe

Material for making the object: Rubber

My explanation: Rubber **is** light **and** flexible

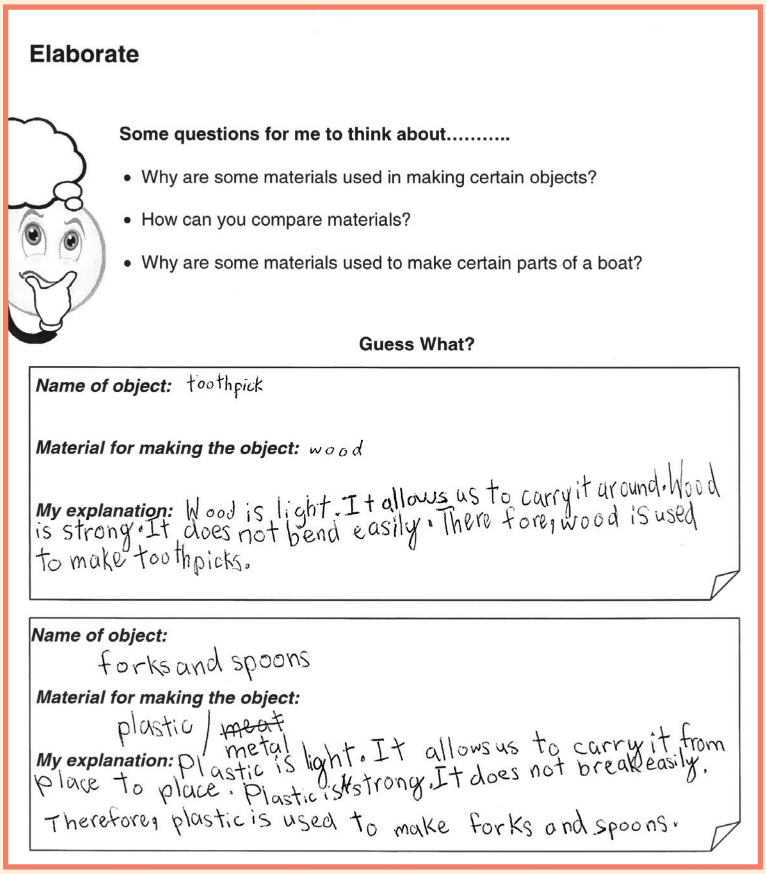
Figure 3. Worksheet completed by a student showing use of terms from a word bank.
(North Vista Primary Science Department, 2014, p. 11).

FINDINGS

Both teachers reported that their students responded well to the scaffolding activities, and they saw there had been an improvement in student learning. The vocabulary given in class was used in complete written explanations more frequently than in previous student writing. In addition, students produced complete sentences which answered the questions posed in the worksheets.

Teacher 1 felt that the word banks and gap-fill activities were useful scaffolds to support students' learning and then applying key scientific terms in their writing. Teacher 1 added that the inquiry had given the students a better understanding of the expectations for writing Science explanations. The students had direct access to the key Science terms in the word banks and there was an observable improvement in the students' ability to pick out the correct words for the gap-fill activities.

Figure 3 is an example of a completed student worksheet showing the language support developed by Teacher 1. The explanation for this example requires the student to identify a material and then give reasons for that choice. Later in the project, the students had



Elaborate

Some questions for me to think about...........

- Why are some materials used in making certain objects?
- How can you compare materials?
- Why are some materials used to make certain parts of a boat?

Guess What?

Name of object: toothpick

Material for making the object: wood

My explanation: Wood is light. It allows us to carry it around. Wood is strong. It does not bend easily. There fore, wood is used to make toothpicks.

Name of object: forks and spoons

Material for making the object: plastic / ~~meat~~ metal

My explanation: Plastic is light. It allows us to carry it from place to place. Plastic is strong. It does not break easily. Therefore, plastic is used to make forks and spoons.

Figure 4. Example of student written work supported with a model answer (North Vista Primary Science Department, 2014, p. 11).

to produce more extended explanations, such as explaining a process. Students needed different forms of scaffolding for writing these extended explanations. The student has chosen the correct properties from the word bank at the top of the worksheet and written these in the gap-fill at the bottom to complete the explanation for rubber being a suitable material for shoes.

Teacher 2 understood the importance of providing and unpacking model answers with her students before a writing activity. After she had walked through the model answers with the whole class, the students were able to produce more detailed written explanations, stating the choice of material and incorporating the properties of the materials in their reasons.

The language support developed by Teacher 2 is illustrated by the example of a student's completed worksheet in Figure 4. In this example, the student has identified the most suitable material for making a toothpick and cutlery, and written a full explanation following the structure shown in the model answer. This was an improvement on the explanations produced by students before language support was introduced, which typically consisted of one or two words.

DISCUSSION

One implication of this inquiry is that literacy support implemented by Science teachers can be successful in improving students' writing. Both teachers found that the language scaffolding introduced in the worksheets enabled students to produce extended and structured explanations. The inquiry also raised important questions. How might literacy support be scaled up to scaffold writing in different subjects and at different levels? How might students' learning gains be sustained? A carefully planned, whole school approach to raising teachers' awareness of the literacy demands of their respective subjects can help provide answers to these questions.

As a result of their inquiry, the teachers have been tasked by the Science department to incorporate literacy support into Science 5E Inquiry packages across other levels. The aim of these packages is to support student writing and thus develop the Science literacy of students. Furthermore, in an effort to sustain the students' learning gains, Teacher 2 also explained to parents how to use the model answers for effective home teaching.

Acknowledgment

The authors would like to thank Francis Yam, the Science HOD at North Vista Primary School, for his support throughout the inquiry.

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Supporting Chemistry Students in Constructing Scientific Explanations

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INQUIRY FOCUS

Two Chemistry teachers at Junyuan Secondary School found that their students had difficulty in explaining scientific concepts when writing assignments and examination answers. Therefore, the teachers decided to investigate how they could help the students to explain concepts clearly and accurately. Through a school-based collaborative inquiry project with ELIS consultants, they were able to design literacy strategies to scaffold students' construction of scientific explanations and examine the effectiveness of these strategies in their teaching.

BACKGROUND

Pearson, Mojé, and Greenleaf (2010) emphasise that teachers play a critical role in integrating literacy skills in subject teaching and learning. Subject teachers are responsible for teaching content and supporting students to meet the language-specific demands of the subject (Chadwick, 2012).

Scaffolding is assisted performance that guides a learner to complete a task and develop the capacity to manage learning independently (Scott, 1997). Scaffolding enables students to accomplish tasks which they would not have been able to manage on their own and help them complete such tasks competently (Michell & Sharpe, 2005). With the recognition of language as a mediating tool that facilitates learning, the notion of language scaffolding has been developed as a way of helping students overcome task difficulties that are related to their relative lack of proficiency in academic language and subject literacy. Language scaffolds built into instructional tasks and supported by teachers' classroom talk can enhance students' learning.

In the context of learning Science, appropriate language scaffolding can guide students to write coherent, well-structured explanations. Scaffolds are meant to be temporary support structures (Hogan & Pressley, 1997), therefore the Chemistry teachers' challenge was how to gradually remove language scaffolding so that their students would eventually be able to complete tasks independently.

PROCEDURE

In their inquiry into supporting students' writing of scientific explanations, the teachers examined the impact of adding language scaffolds to instructional tasks, and guiding students' learning with selected classroom talk moves. This section describes the activities that the teachers undertook as part of the inquiry and presents the strategies introduced in order to address the needs of their students. The research question guiding the teachers' inquiry was: How can teachers support students to meet the literacy demands of scientific explanation in Chemistry?

Context

Twenty-eight Secondary 3 Express and fourteen Secondary 5 Normal (Academic) Chemistry students were the subjects of the teachers' inquiry. The Science curriculum topics the two groups of students were studying were factors affecting 'Speed of Reactions' and 'Chemical Bonding' respectively. The first curriculum topic explores the factors affecting the speed of reactions. Students were expected to explain the effect of changing these factors on the speed of reactions. The second topic focusses on covalent and ionic bonds, and their relation to the physical properties and the electrical conductivity of compounds. For both topics, students had to provide explanations in response to structured and open-ended questions.

Language scaffolding in the task sheets

The teachers added language scaffolds and graphic organisers to worksheets to guide students in organising the relevant content. As shown in Figure 1, the students' task was to describe the effect of increasing the concentration of reagents and reactants on the rate of a reaction. The diagrams in the worksheet showed contrasting representations of low and high concentrations of reactants which provided visual stimuli as a context for the students' explanations. The teachers underlined phrases and clauses representing key scientific language in the worksheet to help students think through, identify and organise scientific concepts. Students rearranged the phrases in sequential order guided by a graphic organiser, which helped them to identify the causes and effects in their explanations. The teachers designed the graphic organiser as a flow chart to guide students in sequencing the cause-effect relationships. The teachers explained that the effects which need to be specified are sequential. A revised worksheet included the use of linking words: 'causes', 'leading to', 'hence' and 'therefore'.

For subsequent tasks on the same worksheet, the scaffolds were gradually removed, as shown in the task examples in Figure 2.

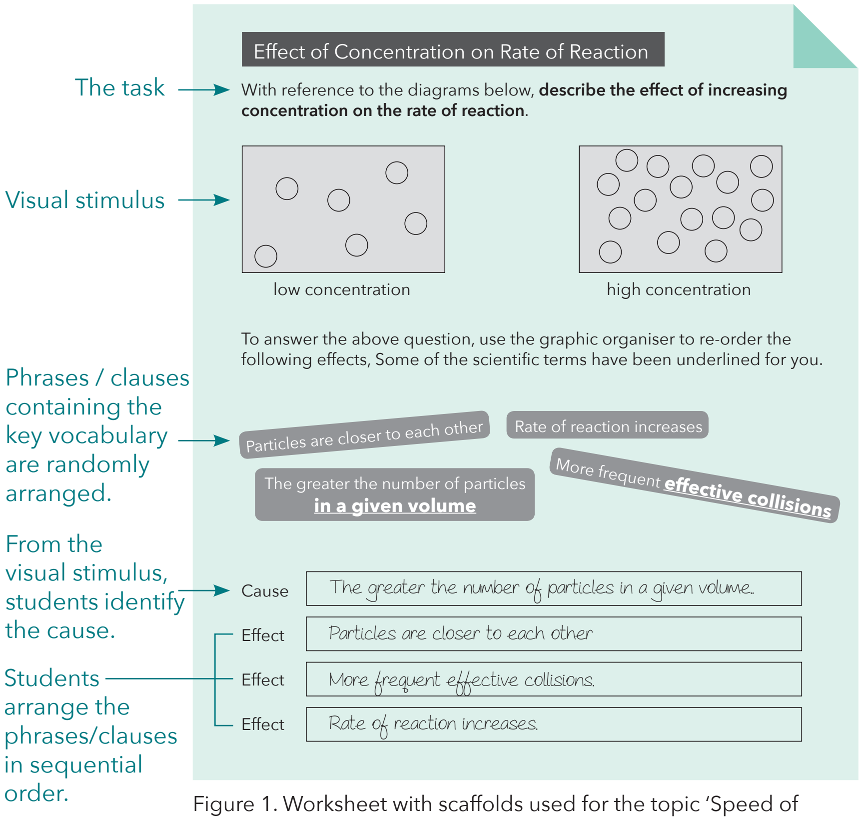

Figure 1. Worksheet with scaffolds used for the topic 'Speed of Reactions'.

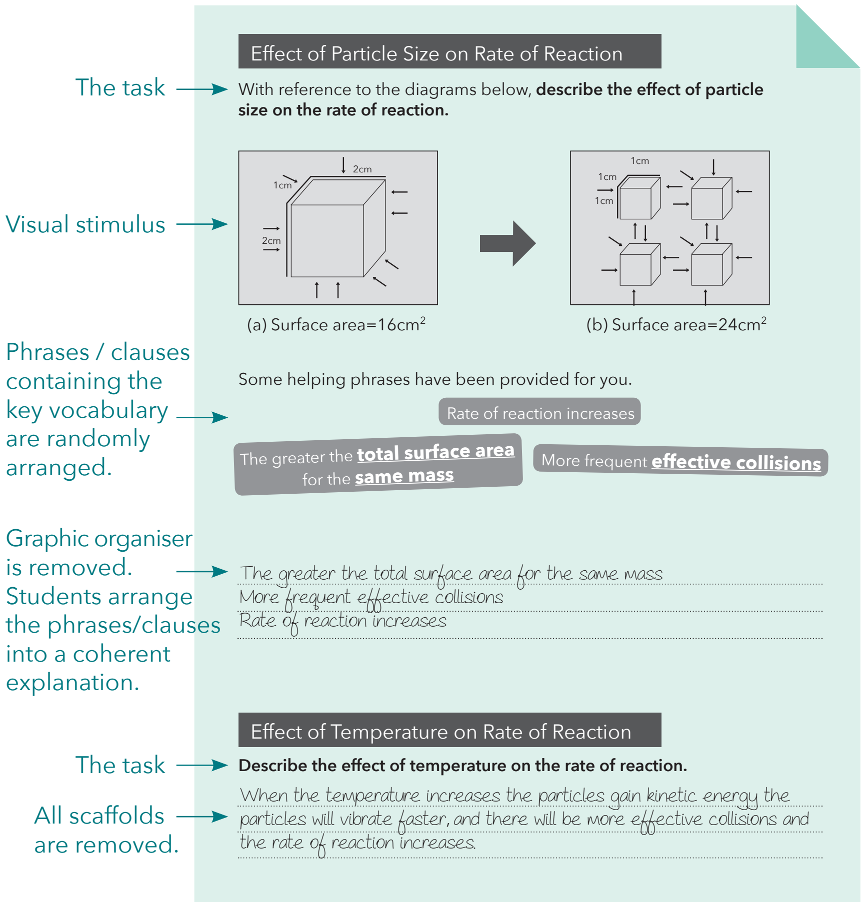

Figure 2. Worksheet for the topic 'Speed of Reactions' with language scaffolding progressively removed.

Language scaffolding through teacher talk

Instructional resources, on their own, may not be sufficient in enabling students to fully understand what is involved. The teachers, through questioning that built on students' responses, focused attention on specific examples of language use to reinforce the use of the worksheets. The teachers became aware of the importance of teacher talk in the classroom, particularly in highlighting the precise language required in scientific explanations. For example, when they asked students to explain what happened to particles when a reaction was carried out at a higher temperature, the students' responses indicated a lack of clarity and precision in understanding. The students had used the terms 'objects' and 'particles' interchangeably, which was imprecise. The focus here is on what is visible at the macro level. Furthermore, the students explained the effects of an increase in temperature on an object to be the 'expansion' of particles, whereas, in fact, the particles absorb energy to move faster. The particles themselves do not 'expand'.

To explore their own practice, teachers recorded themselves teaching the two topics and, with the help of the ELIS consultants, analysed the recorded lessons. This provided a basis for investigating whether the teachers' questioning was guiding the students to develop their understanding or merely testing them.

The teachers learned the importance of talk moves as "strategic ways of asking questions and inviting participation in classroom conversations" (Chapin, O'Connor, and Anderson, 2013, p 11). Questioning frames or prompts can engage students by making learning more dialogic and enabling students to become aware of how explanations are constructed with the appropriate scientific language. The ELIS consultants introduced a set of talk moves and frames for prompting students' responses which they thought would help the teachers to enrich the classroom interaction (see Figure 3).

Talk Moves and Frames for Prompting

Probe for reasoning or evidence

How does data or observation link to what we found out about molten and aqueous states earlier?

Ask a student to restate another student's contribution

Can you put in your own words what you understand from what has been said about bonding and charges?

Guide a student to build on another student's contribution

How does this link to what you know about ionic compounds?

Figure 3. Talk moves and frames for prompting students' explanations provided by ELIS consultants (adapted from Zwiers & Crawford, 2011).

FINDINGS

After giving students a scaffolded writing task that required them to explain a reaction, Teacher 1 noticed that the students wrote more detailed explanations and incorporated key scientific terms, as shown in Figure 4.

In this example, the student has clearly defined the underlying cause, and followed it with a logical and coherent sequence of resulting effects. The student has described the effect of the reaction using scientific language and sequenced the key points with linking words to show cause and effect relationships.

'Effect 1' follows in sequence.

Identifies the 'Cause'.

When magnesium powder is used instead of magnesium ribbon, the surface area of the powdered form increases, so there is more area of contact with hydrochloric acid than compared with ribbon. ***Thus***, this increases the effective particle collision. The rate of reaction ***hence*** increases; ***therefore***, the volume of gas indicated on the graph should be the same as that when magnesium ribbon is used. ***However***, the graph using magnesium powder would have a steeper gradient.

'Effect 2' follows in sequence.
Uses key vocabulary:
'effective particle collision'.

Sums up the explanation and relates back to the question.

Bold words in italics = linking words.

Figure 4. Example of a student's written explanation for scaffolded writing task.

Teachers' perspectives on language scaffolding in task sheets and teacher talk moves

Teacher 2 believed that the design and use of instructional materials to support students' learning required careful consideration, and that the nature and purpose of visual stimuli and graphic organisers were critical. Language scaffolds can catch and focus students' attention; they can also help to scaffold cognitive skills, such as identifying, selecting and organising information.

Teacher 2 became more aware of how questions and responses could be better phrased to deepen students' thinking and sharpen their sensitivity to the structure and language features of scientific explanations.

Students' perspectives of the learning experience

Feedback from the students showed that the majority of them gained from the use of graphic organisers and the practice of breaking down texts into segments. They also reported that they gained from the design of instructional resources which made explicit the necessary information and language required to explain targeted processes. The students felt that the redesigned worksheets:

- Enhanced their learning of content
- Enabled them to better recall content
- Facilitated their construction of clear and coherent written explanations
- Motivated them in their learning.

Teacher 1: "The inquiry project helped me re-examine my teaching of Chemistry. On top of delivering content, I also need to provide language support for my students. The language support will scaffold them to produce more accurate explanations."

Teacher 2: "From this study, I understood my own teacher talk could open up thinking at a deeper level to address the specific demands required of science explanations."

DISCUSSION

Implications of task design

This study showed that the design and use of instructional materials requires careful attention if these are intended as explicit learning support for students. Teachers need to consider how resources with the appropriate language support can be used to address specific learner needs. Such resources can guide students in the initial stages of learning or reinforce understanding of complex concepts in the process of learning. It makes a difference to students' learning how teachers integrate language scaffolds into tasks and materials, and whether they use scaffolds systematically in a staged process. A critical consideration is deciding when to remove the language support.

Implications of teacher talk

Teachers need to strategize how to engage students in productive discussion while making explicit the language-specific demands of tasks. Quality classroom talk has an important role in developing students' ability to reason and communicate scientific reasoning through reinforcing the use of learning tasks and resources. For student learning to be effective, teachers have to design effective questioning sequences that link the visual with the textual in the learning tasks and resources, and engage students in purposeful discussion. In addition, teachers can support students with talk move prompts that encourage elaborated responses. This can lead to sustained classroom interactions that support active knowledge co-construction.

This inquiry highlighted the need to provide students with language support in their subject learning. This can take the form of language scaffolds incorporated into learning resources, as well as meaningful classroom talk that helps students construct and communicate their scientific explanations. The teachers hope that similar studies will be carried out to deepen teachers' understanding of the impact of literacy support on student learning in Science classrooms.

Acknowledgment

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Enhancing Classroom Interactions in Primary Mathematics and Science through Teacher Reflection

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INQUIRY FOCUS

This inquiry examined how teacher reflection improved the quality of classroom interactions in Primary Mathematics and Science lessons. A Mathematics teacher and a Science teacher from St. Andrew's Junior School participated in the inquiry, enhancing their own awareness of classroom interaction.

BACKGROUND

Classroom interaction is an important mode of learning for the student. When a learner is required to explain, elaborate, or defend a position to others, the learner is more likely to integrate and elaborate knowledge in new ways (Vygotsky, 1978).

Students' ability to engage in classroom interaction as a mode of thinking and learning depends a lot on how their teachers interact with them (Nystrand, 1997). Skilful teachers are able to use interactional strategies, such as questioning their students, to more effectively initiate and extend responses that deepen thinking and learning (Saphier, Haley-Speca, & Gower, 2008). Conversely, classroom interactions that are predominantly didactic and teacher-centred can undermine student learning.

Teachers with interactional competence make conscious decisions about how to interact with their students to ensure that the interactions achieve instructional goals (Walsh, 2003). To do so, teachers clearly need to have a good awareness of the interactions in their classrooms. Walsh (2003) also noted that teachers of content subjects, like Mathematics and Science, have recognised the need to understand classroom interactions.

This inquiry recognises that classroom interactions are predominantly didactic and teacher-centred. In Singapore, such interactions occur frequently and persistently in subject classrooms (Kramer-Dahl, Teo, and Chia, 2007). Research also suggests that classroom interactions can be enhanced when teachers become more aware of their own patterns of interaction.

Teachers' awareness can be enhanced through reflective practice, which involves 'reflection-on-action' (Schon, 1983). Teachers can reflect on their classroom interactions after the fact, for example, by considering the thinking and beliefs enacted in their moment-to-moment interactions with students. Reflection-on-action can be enhanced when it is based on data, when it uses appropriate tools to understand the data and when it is done through dialoguing with a fellow professional (Mann & Walsh, 2013).

PROCEDURE

Classroom Interaction Teacher Reflection Tool

The inquiry with the two teachers focused on the use of a reflection tool, the Classroom Interaction Teacher Reflection Tool (CITReT). CITReT uses a coding scheme developed by ELIS and based on the analysis of transcripts found in the literature on classroom discourse. The scheme is derived from the work of Walsh (2006) on the Self Evaluation of Teacher Talk (SETT) grid. CITReT was designed for teachers to use in planning, analysing and reflecting on the interactions in their classrooms. The coding scheme allows teachers to identify 19 features of teacher talk and 13 features of student talk in classroom interactions. It also helps teachers identify four goals or modes of interaction, characterised by different sets of interactional features.

The four interactional modes are:

(a) Managerial

The teacher conveys information related to lesson management.

(b) Knowledge Transmission/Reproduction

The teacher transmits content knowledge and evaluates learners' understanding of transmitted knowledge.

(c) Facilitation of Knowledge Appropriation

The teacher elicits, extends and synthesizes learners' contributions in order to converge upon specific content knowledge.

(d) Facilitation of Knowledge Transformation

The teacher elicits and extends learners' contributions such that learners synthesize ideas and put knowledge to work in other contexts or forms.

Cycles of Teacher Reflection

After a half-day workshop conducted by the ELIS consultants, the Mathematics and Science teachers each participated in two separate cycles of teacher reflection. The Mathematics teacher's lesson in the first cycle was with a Primary 4 class. The topic was the use of the unitary method to solve word problems on fractions. The Science teacher's lesson in the first cycle was with a Primary 5 class. The topic was the water cycle, and students were expected to apply the concepts of evaporation and condensation to describe it.

Each cycle of teacher reflection comprised four stages:

1. Lesson planning

The teachers planned a one-hour lesson. In their lesson plans, they indicated the intended modes for different lesson segments.

2. Lesson implementation and data collection

The teachers conducted their lessons. The ELIS consultants took notes of the classroom interactions, and made audio and video recordings of the lesson. The audio-recordings were subsequently transcribed and used for analysis.

3. Focused data analysis

The ELIS consultants selected segments from each lesson transcript and used CITReT to analyse and code the interactions. They emailed the segments to the teachers to do a similar analysis. A set of questions helped the teachers to reflect on their classroom interactions. These questions were created by the ELIS consultants based on questioning prompts that characterize mentor language (Horn & Metler-Armijo, 2010), with the intention of preparing the teachers to engage in 'learning talk' (Annan, Lai & Robinson, 2003) with the ELIS consultants. Examples of these questions are, 'Where did the discussion stagnate or switch to another mode?' and 'Why do you think this happened?'

4. Reflective dialogue

The teachers discussed their analyses and reflections with the ELIS consultants, and explored how to improve classroom interaction.

FINDINGS

Improvements in the Quality of Interactions in the Mathematics Classroom

In the first Mathematics lesson, classroom interactions enabled students to use mathematical language (e.g. 'parts' and 'whole'). However, teacher questions focusing on performing mathematical operations were frequent, and this limited the scope for extended student explanation and reasoning, as shown in Excerpt 1. Students tended to provide short answers without elaboration, which is a typical feature of the 'knowledge reproduction' mode of interaction.

Excerpt 1 (First Mathematics Lesson)

Math teacher	Gave away? Gave away why? So why did you shade 5 parts that gave away?
Student 1	Cos he gave away 5 parts.
Math teacher	5 parts. Why 5 parts? 3 parts to?
Student 2	The neighbour.

Following the first reflective dialogue on her transcript, the Mathematics teacher carried out another lesson with the same class. The teacher reviewed the students' solutions from a mock test and asked selected students to present and explain their solutions, which represented a range of heuristics. The teacher then asked the class to compare and evaluate the heuristics.

Excerpt 2 (Second Mathematics Lesson)

Math teacher	Now the question is: I want to know why would you prefer the assumption method?
Student 1	Cos assumption method is faster.
Math teacher	What do you mean by faster?
Student 1	For assumption method, it's shorter than guess and check because you only need four steps.

Excerpt 2 shows a transcribed segment of the interactions. In this exchange, the teacher prompted the student to justify his viewpoint, which is a feature typifying the 'facilitation of knowledge appropriation' mode of interaction. The teacher prompts guided the student to explain using mathematical language in terms of the names of the heuristics. More importantly, it also allowed the student to evaluate the heuristics on the basis of the 'socio-mathematical norm' (Yackel & Cobb, 1996) of what counts as mathematically efficient in the Mathematics classroom.

Improvements in the Quality of Interactions in the Science Classroom

In the first Science lesson, the teacher's questions were aimed at the reproduction of expected knowledge. Such questions are a dominant feature of the 'knowledge reproduction' mode of interaction. However, this mode limited the possibility of the teacher following up on students' alternative perspectives. Excerpt 3 shows the teacher focussing on addressing Student 1's possible misconception that it was the 'surface' rather than the water at the surface that would evaporate. The teacher chose not to follow up on Student 2's alternative prediction.

Excerpt 3 (First Science Lesson)

Science teacher	I'm going to check on the paper after 10 minutes. Any pairs want to share your prediction?
Student 1	The exposed surface would evaporate.
Science teacher	Do we talk about the surface evaporating?
Student 2	The water will go through the other side of the paper.
Science teacher	Wait, we are building on [Student 1]'s explanation.

Following the first reflective dialogue, the Science teacher carried out another lesson with the same class. The teacher addressed the topic of scientific inquiry and expected students to apply features of inquiry to deepen their understanding of plant reproduction. In a number of lesson segments, the teacher used discussion to address possible misconceptions, rather than directly instructing the students. In one lesson segment, the teacher followed up on an unexpected question, facilitated extended discussion over 38 turns across multiple students, before consolidating the discussion by connecting it to content knowledge. The 'facilitation of knowledge appropriation' mode of interaction was evident throughout the second lesson.

Excerpt 4 (Second Science Lesson)

Student 1	When they say plant X is unable to disperse its seeds effectively, does it mean it still can disperse just that it won't do it like the last time?
Science teacher	What do you think? [looking at Student 2]
Student 2	The seeds will drop into the water.
Student 3	But then if there's no water, it just drops on the land.

Excerpt 4 shows the Science teacher making a questioning move called the 'reflective toss' (van Zee & Minstrell, 1997) in a typical three-part structure comprising a student utterance, teacher question and additional student utterances. Instead of addressing Student 1's question herself, the teacher shifted the responsibility for thinking back to the student and all those present in class.

DISCUSSION

The improvement in classroom interaction was attributed by the teachers to the cycles of teacher reflection. For example, the Science teacher observed:

> *"I feel we can see the effect quite instantaneously. We only did two lessons with you. But we can see a change in students and improvements in the teacher."*

Some features of the teacher reflection cycles seemed to make a real difference. One such feature was the reflective dialogue between the teacher and the consultant acting as a 'critical friend'. According to Costa and Kallick (1993), a key role of a critical friend is to provide feedback about what seems significant about the practice and provide a lens that helps to elevate the work.

Excerpt 5 shows the ELIS consultant as critical friend, prompting the teacher to identify less effective classroom discourse and suggest ways to improve the interaction. After giving feedback on the nature of the teacher's questions, the ELIS Consultant proceeded by prompting and supporting the teacher in exploring ways to improve questioning and encourage student discussion. The dialogue led to the strategy of asking students to 'discuss the pros and cons'. Following the reflective dialogue, the teacher carried out the strategy to good effect in the second lesson.

Excerpt 5 (First Reflective Dialogue with the Mathematics teacher)

Consultant	But can you think of ways which you could have asked questions here which were not as closed?
Math teacher	I know one way is to ask for alternative solutions.
Consultant	Of course you could juxtapose different ways of solving and then see what the advantages are.
Math teacher	Perhaps, one way to make this lesson more open-ended is to ask what other solutions they can come up with and discuss the pros and cons.

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