ELIS
ENGLISH LANGUAGE INSTITUTE OF SINGAPORE

# SUBJECT LITERACY
## INQUIRY DIGEST

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# FOREWORD

In primary and secondary schools which have joined the Whole School Approach to Effective Communication in English (WSA-EC) initiative supported by ELIS, a growing number of teachers are investigating how they can develop their students' subject literacy. Working with ideas from our professional learning courses, they explore subject-specific language and literacy, as well as opening up talk for learning and integrating talk with writing in their subject classrooms.

In this third volume of the Subject Literacy Inquiry Digest, the featured authors report on the use of different strategies to scaffold their students' learning in Art, Science and Mathematics, and reflect on the efficacy of the strategies.

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# CONTENTS

**ARTICLE 1 · pp. 2 - 7**

Helping Students to Talk about Art in Primary Four Classrooms

**ARTICLE 2 · pp. 8 - 15**

Enhancing Students' Conceptual Understanding with Science Notebooks

**ARTICLE 3 · pp. 16 - 24**

Using Talk Moves to Promote Mathematical Reasoning in a Secondary School Classroom

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# Helping Students to Talk about Art in Primary Four Classrooms

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## INQUIRY FOCUS

An Art teacher in Northland Primary School observed that many students could only provide brief answers when talking about works of art, even when thinking routines were employed. To help students develop the language they need to describe and interpret artworks, she collaborated with ELIS to develop language support strategies which were implemented in all Primary Four classrooms. This article reports on their joint inquiry into the effectiveness of this intervention.

## BACKGROUND

One of the goals of the Primary Art syllabus is to develop in students the skills to describe and interpret works of art (MOE, 2008). Towards this end, Art teachers frequently rely on artful thinking routines (Tishman, 2006), such as See-Think-Wonder (STW), to encourage students to make careful observations and thoughtful interpretations about what they see. However, as one Art Senior Teacher at Northland Primary School has noticed, the use of such routines can yield mixed results. Most of the time, only a few naturally expressive students were able to provide extended responses; the majority of students gave one-word answers or short phrases, despite efforts by the teacher to model and encourage more substantial responses. Apparently, more can be done to help students talk about art.

Scholars have acknowledged that each discipline has unique patterns of thinking and language use. (Schleppegrell, 2004; Shanahan & Shanahan, 2012). This implies that students need teacher support to learn the ways of thinking and communicating that are particular to every subject. One of the aims of Art as a school subject is to promote visual literacy so that students can "observe, understand and make meaning" of what they see (MOE, 2008, p. 2). Students should also be able to "describe" their observations and interpretations (MOE, 2008, p. 3). In order to do this well, students would need to know how to observe and make meaning of artworks, and possess the language resources to talk about their ideas in ways that are valued in an Art classroom. As these ways of thinking and talking are unlikely to be part of students' everyday experiences, they would need teacher support to learn them. Such support can take the form of instructional scaffolding which attends to the cognitive and linguistic demands of the subject (Gibbons, 2002; Chadwick, 2012). Teachers can also engage learners in classroom conversations which foster learning (Zwiers & Crawford, 2011).

## PROCEDURE

This inquiry project began after the Art Senior Teacher attended the ELIS professional learning course, *Language and Literacy in Subject Classrooms*. Recognizing the importance of language support and talk for learning, she partnered with an ELIS consultant to work out how she might better help her students talk about art. Together, they identified the language and literacy skills needed to observe, interpret and describe artworks. They then designed resources and employed strategies that supported student learning. In order to investigate the effectiveness of their intervention, they embarked on an inquiry project, guided by the question: *How can Art teachers help students to articulate more elaborate answers when talking about artworks?* The resources and strategies were integrated into an eight-lesson unit on Batik for all seven Primary 4 classrooms, involving four teachers and two hundred and thirty-seven students in total. While the teachers monitored student learning throughout the semester, an STW response sheet (see Figure 1) was given to students at the beginning and end of the unit to assess the students' ability to talk independently about artworks.

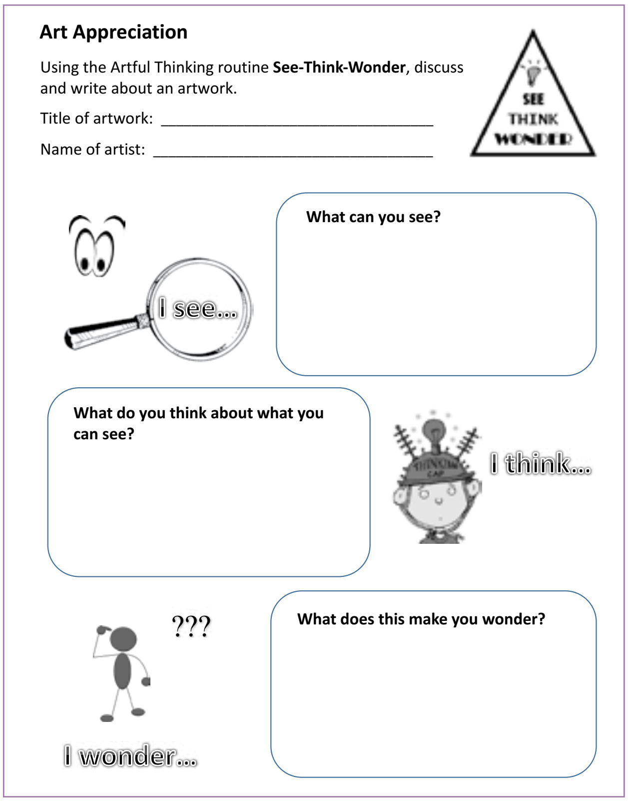


Figure 1. The See-Think-Wonder response sheet given to students before and after the lesson unit.

## RESOURCES

Two types of resources were developed to help students describe and interpret artworks. The first type, called the Art Talk Charts, were posters featuring the content vocabulary and functional language students would need to talk about art; the second was a card game designed to encourage students to talk about artworks and to apply the appropriate language and skills to do so.

### Art Talk Charts

The Art Talk Charts comprised three sets of posters. One set explicated the elements of art (EOA) and the principles of design (POD). These provided students with the vocabulary and subject knowledge resources upon which to draw when making observations of and interpreting artworks (see Figure 2 for an example). Another set of charts featured guiding questions for each part of the STW routine, spelling out the cognitive steps students could take when making observations of or interpreting an artwork (see Figure 3 for an example). The third set of charts displayed the sentence stems students could use when articulating their views (see Figure 4 for an example). All the posters were prominently displayed in the Art classrooms. The teachers referred to them regularly and instructed their students to do the same.

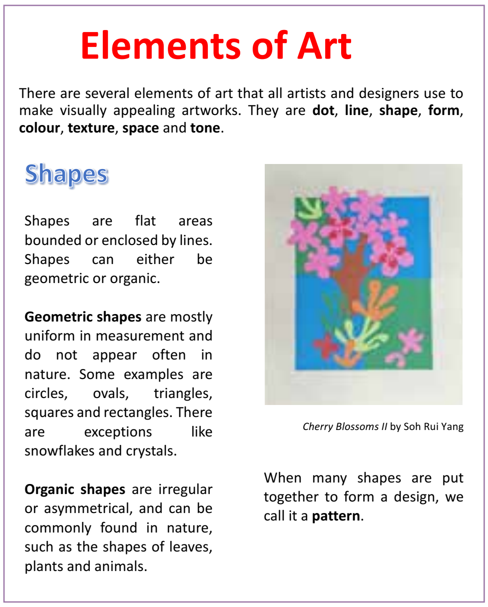


Figure 2. An Art Talk Chart on shapes, an element of art.

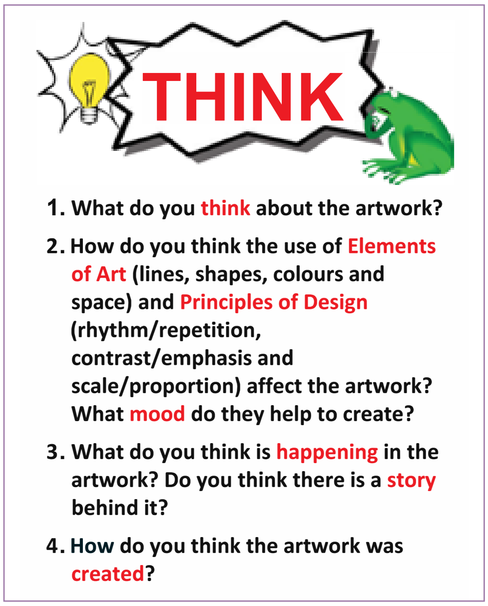


Figure 3. An Art Talk Chart featuring guiding questions for the Think part of the STW routine.

# SEE

## Sentence Stems

- I can see _______.
- I observe that _______.
- I notice that _______.
- The first thing that I notice is _______.
- The first thing that caught my eye is _______.
- There is/are _______.
- The artwork looks _______.
- The similarities/differences of these two artworks are _______.
- I see/observe/notice the use of _______ to _______.
- The _______ looks like _______ and reminds me of _______.

Figure 4. An Art Talk Chart providing sentence stems to help students articulate their observation of an artwork.

### Art Talk Game

The Art Talk Game consisted of a set of cards designed to facilitate group discussions about artworks, affording students more opportunities to practice newly acquired language and skills. The brightly coloured cards displayed either an element of art or a principle of design on one side, and the STW prompts on the other (see Figure 5 for an example). Students played this game in groups of four to six and were each given a selection of cards. They took turns to talk about an artwork, picking out a card each time and responding to its prompts. If a student used the appropriate vocabulary and functional language to respond to the prompts on the card, he or she could discard it. The first student to get rid of all the cards would win the game.

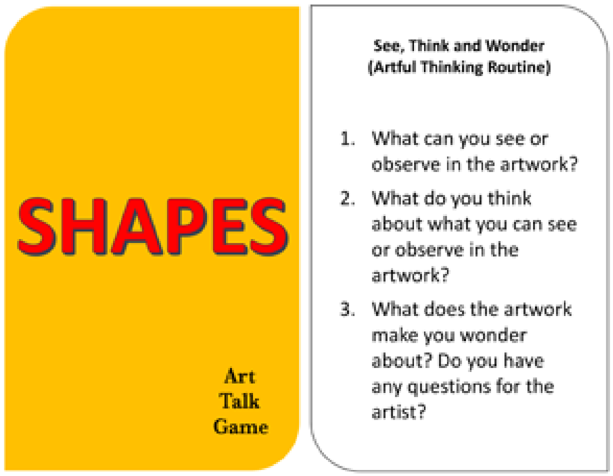


Figure 5. A card from the Art Talk Game.

### Strategies

The teachers relied on a variety of pedagogical practices to help their students develop the skills and language needed to talk about batik art. Two important practices were teacher modelling and classroom discussions. Teacher modelling ensured that the ways to think and talk about artworks were made explicit; classroom discussions provided students with opportunities for dialogic interactions which deepened their learning.

### LESSON SEQUENCE

Prior to the start of the unit, the students were asked to talk about two batik paintings using the STW routine. Individually, they wrote their responses on the STW response sheet and submitted it to their teacher.

During the first two lessons, students were introduced to batik art as well as the EOA and POD. Through a jigsaw activity, they worked in groups to learn and teach one another about the art elements and design principles. The teacher referred to the Art Talk Charts and modelled how she would use the information on the charts to describe and make meaning of batik paintings. She also engaged students in lively discussions, guiding and encouraging them to use the language and prompts that had been introduced.

In the next four lessons, students learned about batik painting techniques and created their own individual batik artworks. They also engaged in small group discussions to talk about their own paintings and those of their peers using rubrics they had created. They were encouraged to use appropriate language and could refer to the Art Talk Charts for help. The teacher monitored student learning and provided guidance when necessary.

The seventh lesson provided the students with more opportunities to describe and interpret artworks through playing the Art Talk Game. The winners from each group were invited to present their views in front of the whole class. The rest of the students asked questions and provided comments after each presentation.

In the final lesson, several artworks featuring the use of dots were introduced to the students. Using the knowledge, language and skills they had learned throughout the semester, the students compared the artworks and shared their perspectives in a class discussion. As before, they were then given the STW response sheet to record their interpretation of the same paintings (see Figure 6 for one of the paintings).

The teachers collected this second set of response sheets and compared the answers with those from the first day. They analysed the student writing to see if they could write more elaborate answers, using the skills and language that they had learned.

Figure 6: A painting accompanying the STW response sheet.

## FINDINGS

All four teachers noted improvements in their students' responses, whether verbal or written, for both paintings. Compared to what they were able to produce prior to the intervention, their subsequent answers were significantly more elaborate, demonstrating a better grasp of what it means to think and talk about an artwork. When asked to present their ideas to the class, they were also more willing, articulate and confident. Importantly, these improvements were observed across all types of learners. In the next section, we present examples of a high-progress student and a low-progress student responding to one of the paintings. The two examples illustrate the changes in students' answers that were typical across the first and second STW response sheets. All sentence stems from the Art Talk Charts are underlined and vocabulary items related to EOA or POD are indicated in bold.

### STUDENT A (HIGH-PROGRESS)

| STW Prompt | First Response Sheet Answer | Second Response Sheet Answer |
|---|---|---|
| SEE<br><br>What can you see? | A fish<br><br>One pink flower<br><br>One blue flower | <u>I can see</u> that the drawing is **outlined** with **bold orange lines**.<br><br><u>I observe that</u> the **shapes** drawn are **organic** as they are from **nature**.<br><br><u>The repeated use of</u> **floral motifs** <u>creates</u> **a sense of rhythm**.<br><br><u>The use of</u> **contrasting colours** give **emphasis** or **focus** to the artwork.<br><br>The **dots** in the **background** create a **beautiful design** for the painting. |

*In her first STW response sheet, Student A gave short phrases as answers to the "see" question.*

*At the end of the unit, she was able to use the sentence stems to create complete sentences. There was also evidence of the use of art vocabulary related to EOA and POD.*

| STW Prompt | First Response Sheet Answer | Second Response Sheet Answer |
|---|---|---|
| THINK<br><br>What do you think about what you can see? | The artist used dots for the **background**.<br><br>The artist spent lots of time on this artwork.<br><br>This artwork is very creative. | <u>I feel</u> that the **thick bold orange outlines** and **contrasting blue background** help to **define** the artwork, making the flowers and the leaves **stand out**. |

*At the start of the unit, Student A was using a more direct approach to interpret the artwork. The adjective "creative" was used, but there was no attempt to elaborate on why she thought it was so.*

*After the lessons, she was able to make a connection between how the use of art elements (lines and colours) were used to create a certain artistic effect, making the objects "stand out."*

| STW Prompt | First Response Sheet Answer | Second Response Sheet Answer |
|---|---|---|
| WONDER<br><br>What does this make you wonder? | How long did the artist take to finish this artwork?<br><br>Whether the painting has been sold? | <u>I wonder what</u> the artist was thinking when he did the painting.<br><br>What **materials** and **techniques** did the artist use to create the **blending effect** on the flower petals? |

*Before the intervention, Student A was more concerned about how long the artist took to paint the artwork and whether it was sold.*

*After the intervention, she was able to express her curiosity about the artistic process and the materials and techniques used to achieve a blended effect.*

STUDENT B (LOW-PROGRESS)

| STW Prompt | First Response Sheet Answer | Second Response Sheet Answer |
|---|---|---|
| SEE<br><br>What can you see? | A sea<br><br>Flowers<br><br>Coral reef | I can see flowers and leaves.<br><br>I observe **patterns like dots** on the flowers and leaves.<br><br>There is a **repetition** of leaves. |

*At first, Student B was giving one-word answers or short phrases.*

*At the end of the unit, however, he was able to provide a more detailed description of his observation of the artwork, using his knowledge of EOA and POD.*

| STW Prompt | First Response Sheet Answer | Second Response Sheet Answer |
|---|---|---|
| THINK<br><br>What do you think about what you can see? | Half land and half sea.<br><br>It is very beautiful.<br><br>This took a long time to make. | I think the **bold orange outlines contrast** with the **dark blue background**.<br><br>The **blue dots resemble** the water.<br><br>The small plants are actually algae. |

*On the first day, Student B was sharing vague thoughts about the artwork. The adjective "beautiful" was used but there was no attempt to explain why he thought it was so.*

*On the final day of the unit, he was able to make meaning of his observation with what he had learnt about colours and lines in art.*

| STW Prompt | First Response Sheet Answer | Second Response Sheet Answer |
|---|---|---|
| WONDER<br><br>What does this make you wonder? | Who is the artist?<br><br>What is the title?<br><br>How hard is it? | I wonder if the artist painted this artwork **based on nature**.<br><br>I wonder if this artwork is painted on a fabric. |

*At first, Student B was more concerned about the name of the artist and the title of the artwork. He also wondered "how hard" it was, probably thinking that the artistic process was a complicated one.*

*At the end of the unit, he was able to focus on the subject matter and the theme of nature found in the artwork. He also recognized that the artwork could be a fabric design.*

Generally, the teachers noted that the answers in the second STW response sheet were more detailed and expressed in complete sentences. In fact, while students could only offer short phrases or one word answers at first, they were able to write responses that were several sentences long at the end of the unit, using the sentence stems and newly acquired vocabulary to do so. By the end of the unit, most of the students were able to draw on their knowledge of the EOA and POD to describe the artworks and used the appropriate language to do so. However, some students tended to restrict their expressions to the words and phrases provided by the teacher. The teachers deduced that this could be due to a lack of facility with the language or a fear of getting a wrong answer. To mitigate this unintended consequence in the future, they proposed exposing students to more examples of how art can be described, as well as encouraging them to share original views more freely.

## DISCUSSION

The findings of this study illustrate the benefits of providing language and literacy support in the Primary Art classroom. The Art teachers involved in the study found that the explicit teaching of content vocabulary and functional language for Art was effective in helping students talk about artworks. However, they noted the importance of encouraging originality and cautioned against being too prescriptive, so as not to restrict student responses.

The jigsaw group discussions about EOA and POD seemed to help students learn the concepts and vocabulary more effectively, as evidenced by their more extended and precise answers in the second STW response sheet. Feedback from students revealed that they enjoyed the interaction of the Art Talk Game and learned how to use words and sentence stems through playing it. This suggested that the teacher-guided discussions and the use of the game promoted student engagement with the subject and deepened their learning.

Encouraged by the results, all four Art teachers felt that such support ought to be provided across all six levels. They plan to develop more resources and teach the language of art progressively. These materials and activities, designed to match the themes and topics for each level, will be integrated into the school's Art curriculum. Noting the importance of classroom talk for learning, they intend to conduct group discussions more often. They are also refining the Art Talk Game and exploring more ways to engage students in talking about art.

### Acknowledgement

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# Enhancing Students' Conceptual Understanding with Science Notebooks

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## INQUIRY FOCUS

Upper Primary Science teachers at Ang Mo Kio Primary School noted that their students had difficulty retaining science concepts. Students also had misconceptions relating to the science content. With the support of an ELIS consultant, the teachers explored how they could identify the gaps in their students' conceptual understanding early in the learning process, and facilitate students' use of the appropriate content vocabulary to communicate science content through the use of science notebooks. The research questions guiding the teachers' inquiry were: How can teachers use science notebooks to enhance students' conceptual understanding in Primary Science? What benefits do teachers and students perceive in the use of notebooks?

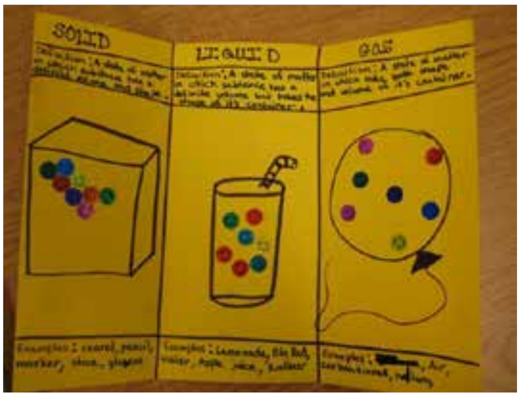
## BACKGROUND

In learning science, students have to process and communicate their conceptual understanding of scientific content. This can be overwhelming for young learners as they seek to make sense of different types of information. Science teachers have explored the practice of requiring students to create a science notebook, in which the students record and express their understanding of new concepts (Fulton & Campbell, 2014; Morrison, 2008; Shepardson & Britsch, 2000). Students' science notebooks incorporate text as well as visual representations (drawings, diagrams, graphs, and tables) for science curriculum topics. The students' notebooks can reveal what they know about the content and the practice has been shown to be an effective strategy for helping students learn science (Hargrove & Nesbit, 2003; Morrison, 2008; Shepardson & Britsch, 2000).

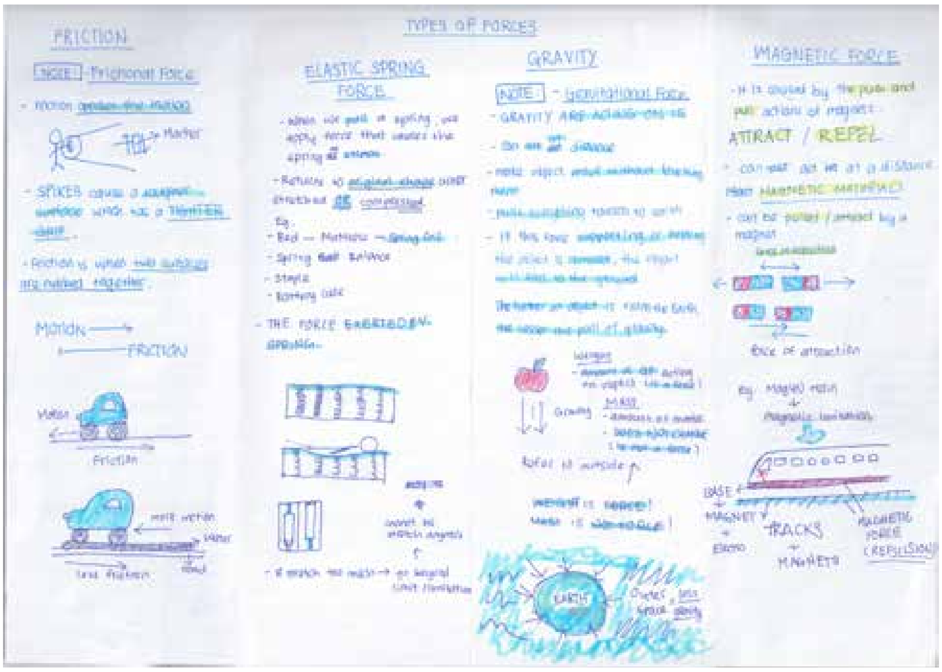
By capturing information about the students' learning experiences with the scientific phenomena, science notebooks "imitate the journals that actual scientists use as they explore the world" (Hargrove & Nesbit, 2003, p. 3). Science notebooks allow teachers to "assess students' understanding and provide the feedback students need for improving their performance" (Ruiz-Primo, Li, & Shavelson, 2002, p. 24). The use of notebooks can forge links between science content and literacy, as a "knowledge transforming form of writing that provides an appropriate opportunity for students to develop voice in the process of constructing meaning from their experiences with the science phenomena" (Klentschy & Molina-De La Torre, 2004, p. 352). Students learn to make decisions about their language use as they access and meaningfully engage with science ideas.

In this article, our focus is on the value of science notebooks in strengthening Singapore students' use of language to convey their understanding of the science they experience. Figure 1 illustrates the multimodal nature of the literacy being developed through some examples of student's notebook entries from the primary school in the study.


A Primary 3 student's notebook entry on the body coverings of animals.




A Primary 4 student's notebook entry on the different states of matter.




A Primary 6 student's notebook entry on types of forces.

Figure 1. Examples of the multimodal nature of students' notebook entries.

> Science notebooks are a "knowledge-transforming form of writing that provides an appropriate opportunity for students to develop voice in the process of constructing meaning from their experiences with the science phenomena" (Klentschy & Molina-De La Torre, 2004, p. 352)

## PROCEDURE

This section presents the context for the inquiry and describes the teachers' efforts at integrating science notebooks into their classrooms.

### SCHOOL CONTEXT

The study involved 80 Primary Five students from two classes (one high-progress and one mixed-progress) and 75 Primary Six students from two classes (one high-progress and the other low-progress). The two teachers conducting the study were supported by their former department Head of Science. Primary Five students used science notebooks at the appropriate stage to support their learning as elaborated below whereas Primary Six students created their own visual representations as a way to revise the topic. The lessons described in this article were focused on the topic of *Cells*.

The teachers jointly planned lessons integrating the use of science notebooks into their lessons to support students' learning in a systematic and organised way. The teachers identified a specific scientific concept as the focus of the targeted topic. The teachers used the 5E Inquiry-based Instructional Model (Figure 2) to guide them in their planning. After students learned about the different parts of cells in the Engage and Explore stages, the teachers aimed to integrate students' creation of science notebooks with their teaching. At the Explain stage, therefore, the teachers used templates (see Figure 3) and instructional resources for the science notebooks in order to develop students' understanding of the different functions of parts of a cell.

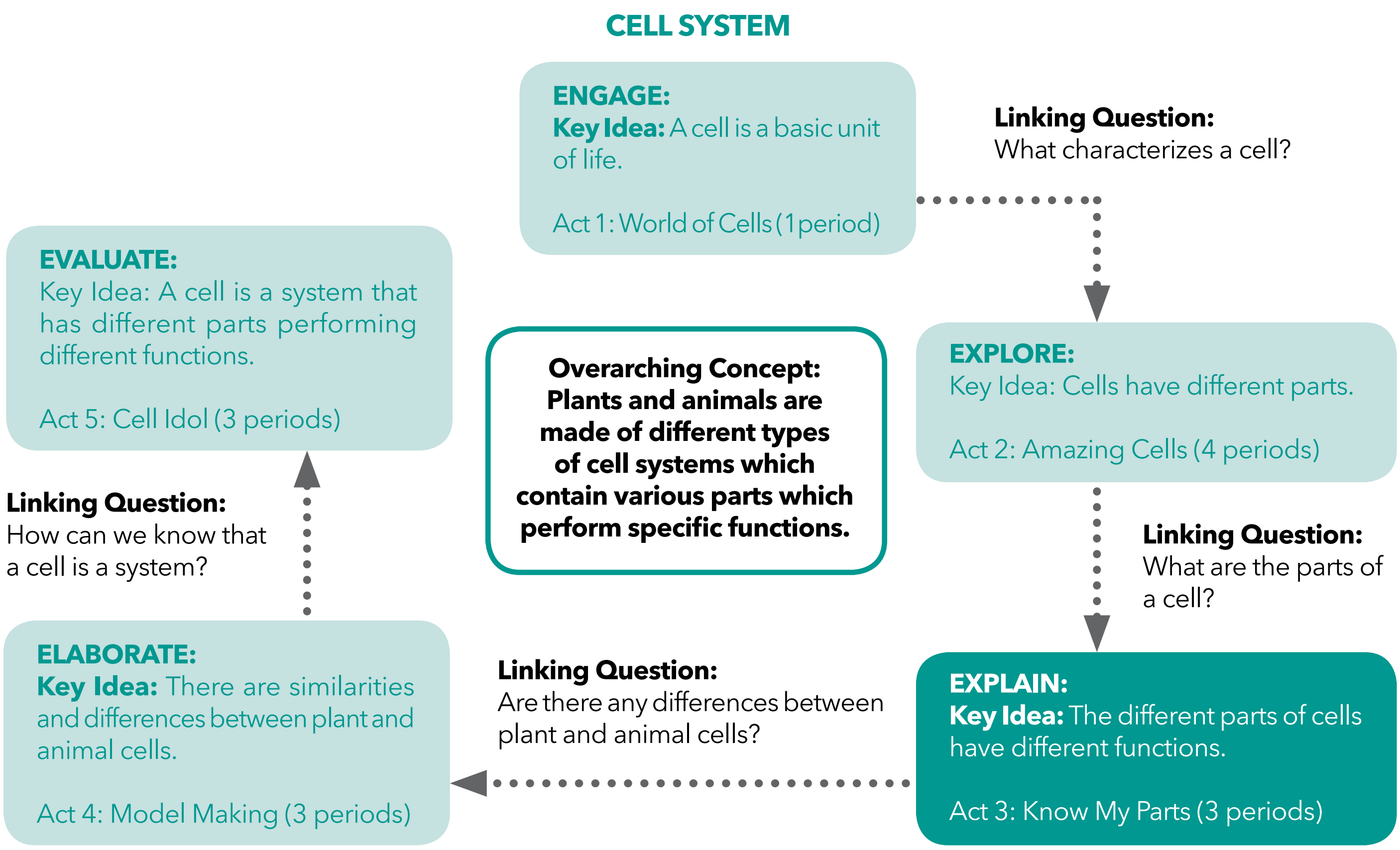



Figure 2. 5E Inquiry-based Instructional Model (Bybee et al, 2006) adapted from CPDD (2009) for teaching cells.

Students folded the cut-outs from the templates (Figure 3), and wrote the labels of the relevant parts and descriptions of the corresponding functions of the parts of animal and plant cells (Figure 4). As seen here, students wrote the functions of the various parts of a plant cell - cytoplasm, cell wall, cell membrane, chloroplasts and nucleus - on the cut-outs and pasted them on the template with lines showing where they understood these were in a plant cell.

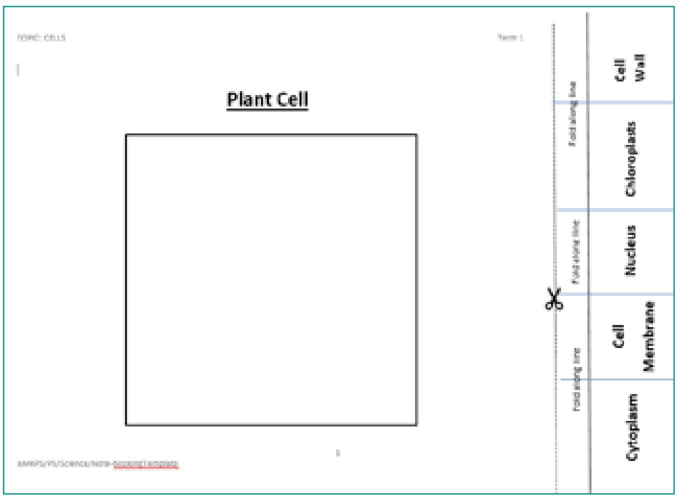



Figure 3. Template for construction of the notebook showing features of a plant cell.

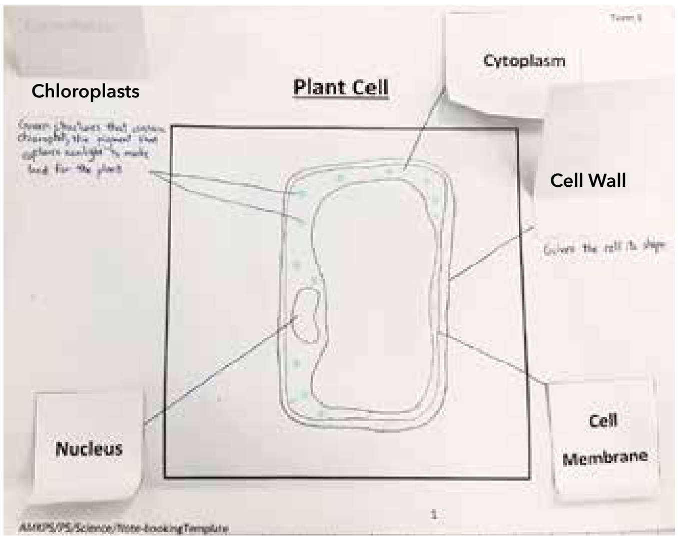



Figure 4. A student's notebook entry using cut-outs to label parts of a plant cell.

Guided by teachers, students participated in hands-on activities, representing and consolidating what they had learnt through the process of creating a science notebook. First, they discussed their ideas in groups of four to five students. Then, individually, they made decisions about what to represent and how their ideas would take shape through their written texts and visual representations. High-progress students selected their own materials, explained their justification for the materials and created notebook entries based on their own designs. Low-progress students used the templates provided.

After completing their science notebook entries, the students provided input on other students' notebook entries and responded to similar feedback from their peers in a gallery walk. To reinforce their learning, students progressed from using the template cut-outs to drawing their notebook entries and drafting written descriptions of the various parts and functions of plant and animal cells. For example, they were asked to:

(a) Name two parts that can be found in a green leaf plant cell but not in an animal cell.

(b) State the function of <u>one</u> of the parts that is not found in the animal cell.

Teachers' perspectives on the use of science notebooks were elicited from teacher interviews and students' perspectives were drawn from students' written reflections.

## FINDINGS

### MONITORING STUDENTS' CONCEPTUAL UNDERSTANDING AND LANGUAGE USE

With the ELIS consultant's help, teachers examined students' notebooks guided by a framework developed by ELIS to monitor conceptual understanding, language use and visual representations. (Figure 5)

| Area/Level | Competent | Emerging | Beginner |
|---|---|---|---|
| **Science concepts** | The written text demonstrated understanding of **MOST** of the science concepts accurately and attempted to show the relationship between concepts. | The written text demonstrated understanding of **SOME** of the science concepts accurately and attempted to show some relationship between concepts. | The written text demonstrated **LITTLE** / **NO** understanding of science concepts, with no attempts at showing the relationship between concepts. |
| **Content vocabulary** | Appropriate scientific vocabulary was used **MOSTLY** accurately to convey understanding of the science concept. | Appropriate scientific vocabulary was used, with **SOME** minor lapses, to convey understanding of the science concept. | **LITTLE** / **NO** use of appropriate scientific vocabulary to convey understanding of the science concepts. |
| **Visual representations** | Visual representations are **MOSTLY** accurate and labelled with the relevant details. | Visual representations are **PARTIALLY** accurate and labelled with **SOME** details. | There are **FEW** / **NO** visual representations with no details labelled. |

Figure 5. Criteria for monitoring students' conceptual understanding and language use (Adapted from Ruiz-Primo, Li & Shavelson, 2002 & Reed, 2012).

The criterion of 'Science concepts' in Figure 5 focuses on accurate understanding of science concepts and relationships between concepts. For 'Content vocabulary', the emphasis is on the use of what is appropriate to convey understanding of the science concept. With regard to 'Visual representations', the interest is in the extent to which these are accurate and the specificity of details in labels provided.

#### Example of student's work for the topic of *Cells*

The following example of a student's work for the topic of *Cells* illustrates the student's ability in specific areas. Referring to the criteria provided in the framework, teachers could determine the level of competency students exhibited in those areas. They could then follow up to address students' weaknesses and provide the support required to meet students' learning needs.

With regard to the criteria shown in Figure 5, the student's work would be deemed competent. The student's notebook entry in Figure 6 illustrates an accurate understanding of the composition of animal cells through the visual representation. There is the use of appropriate content vocabulary. The student makes explicit the relevant details of the corresponding functions of the parts making up the cell.

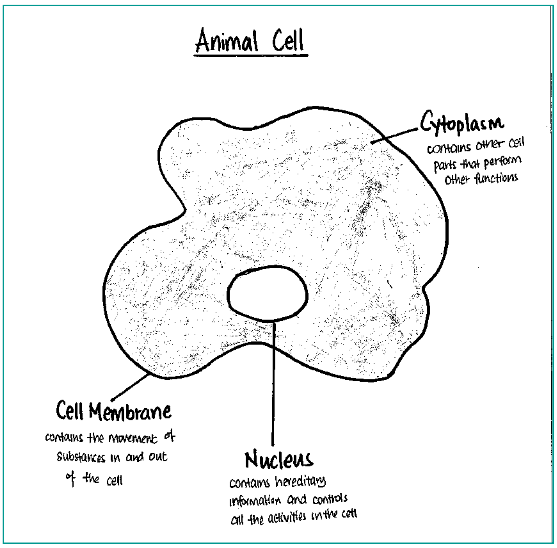



Figure 6. A student's notebook entry on an animal cell.

## HOW USING SCIENCE NOTEBOOKS BENEFITS TEACHERS AND STUDENTS

Teachers perceived the use of science notebooks as beneficial in several ways. Students felt that the science notebooks enhanced their learning. The sections that follow provide evidence for these findings drawn from interviews with the teachers and the reflections written by the students.

### Teachers' perspectives

Teachers gained from having opportunities to assess pupils' conceptual understanding and reinforce content recall and consolidation:

> I usually use notebooking at the end of a topic. I get my pupils to reflect on everything they had done on that topic and to consolidate the important concepts taught. The intentional notebooking helps them in answering their MCQ and open-ended questions as they remember the content from each topic, have it at their fingertips and can answer the questions.

> Notebooking also helps them consolidate what they have learnt and the learning is more focused. As pupils have to remember what they have been taught in previous lessons, notebooking helps to focus on essential and important concepts.

At the same time, science notebooks enabled teachers to surface misconceptions students had in order for the appropriate follow-up action to be taken:

> Teachers will assess students' work and identify misconceptions, if any. Teachers will usually provide feedback for further improvement so that students can increase their understanding of that topic.

Furthermore, teachers could stretch high-progress students by helping them to express conceptual understanding through exercising their creativity in constructing science notebooks:

> Teachers can also stretch the high-progress pupils by getting them to do notebooking on their own. Students' thinking will be made visible. They will be 'coerced' into consolidating the ideas that they have for a particular topic and present them in an engaging manner so that they can use their work for revision.

> You will see a variation of products. Some write in prose while others prefer to write in point form. Some pupils who are better at drawing can illustrate science concepts while others who cannot draw will print pictures from the internet or cut pictures out from magazines. Students are given the freedom to be creative.

Science notebooks engage lower-progress students and help them remember facts and reflect on their learning:

> The weaker students find it fun and enjoy it. Notebooking is also meant as a self-reflection on the lessons taught and to pen down the concepts they have understood in a creative way.

**Students' perspectives**

Individual reflections written by the students showed that they gained from being able to address task demands with enhanced conceptual understanding:

> I am able to answer Science questions more fully than before. My answers are more complete and to the point.

> I am able to answer the questions better as I have a deeper understanding of the science concepts.

> I can understand the question more easily and understand the science concept behind it so that my answer will be correct. I begin to understand more of each topic and can use what my teacher taught me in my written work.

Students also developed an awareness of the need for precision through using scientific language:

> I use more scientific words.
>
> She has made me identify that science language features are different from English language features. For example, hardness in science is about being able to withstand scratching; hardness in English is the opposite of soft.

Students highlighted the use of visual representations by the teacher as helping them learn science (see Figure 7 for examples):

> In order to help me make sense of information in visuals, my teacher has presented the information in diagrams, mind maps. Apart from these, my teacher also uses flow chart to demonstrate to me how to identify the object or its specific category.
>
> Teacher has allowed me to see that science concepts does not always have to be represented in sentences. It can come as a flow chart, concept map.

Students also identified the organization of content as a specific benefit:

> The visuals will help us organize the information clearly.

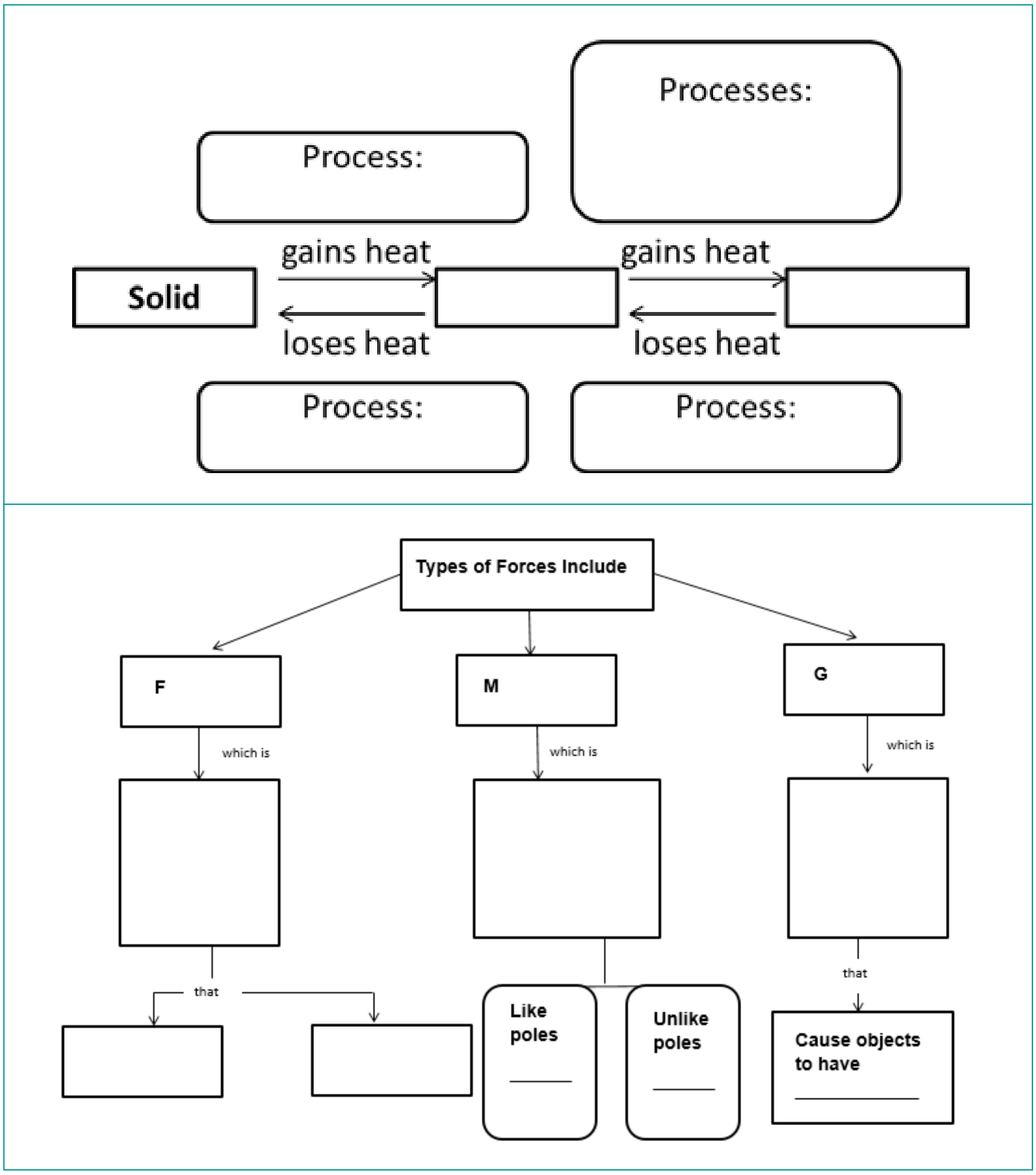



Figure 7. Two examples of visual representations provided by teachers.

## DISCUSSION

This section discusses the pedagogical implications arising from the use of science notebooks with recommendations for addressing challenges encountered by teachers.

Teachers encountered challenges using science notebooks in their classes. Given that students may require much guidance, teachers would need to spend more time to help students understand what they need to do.

One teacher believed that careful thought and planning must be put in place for the effective integration of science notebooks into the science curriculum. If teachers see the notebooks as a separate or additional activity isolated from the current curriculum, they may end up with insufficient time to meet the demands of science notebooks.

Another teacher was convinced that being intentional in ensuring that writing science notebooks builds on the skills that are identified as relevant in the curriculum makes the practice worthwhile. At the same time, helping students to create their own science notebooks provides opportunities to practise using the content vocabulary needed to access and meaningfully engage with science concepts.

In addition, templates with relevant samples enable teachers to guide students in their initial notebook attempts, particularly for weaker students. Over time, as teachers and students become more familiar with science notebooks, greater leeway could be given, with teachers providing the space for students to experiment with creative expressions for representing their understanding of science concepts.

This study also surfaced the need for differentiated support for high and low-progress students to address students' learning needs. When dealing with students of differing ability, flexibility should be given to high-progress students to extend their learning by exploring different ways of representing their conceptual understanding so long as they are able to focus on the key concepts. In the study, these students selected their own materials and required less time in class to construct their notebook entries. Low-progress students, on the other hand, would benefit from more structured guidance to scaffold students' efforts in achieving the desired learning outcomes.

With careful planning, science notebooks can enable students to internalise, meaningfully engage with and creatively construct their understanding of science content. Students can also be more effectively engaged in their learning as they acquire scientific ways of being, viewing, writing and thinking.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# Using Talk Moves to Promote Mathematical Reasoning in a Secondary School Classroom

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## INQUIRY FOCUS

A Secondary One mathematics teacher observed that her students tended to give short responses to her questions during class discussions. Through a collaborative inquiry project with ELIS, the teacher explored how to use talk moves to help students articulate their mathematical reasoning. This article outlines some of the challenges the teacher faced and discusses factors that need to be considered when implementing productive mathematics talk in the classroom.

## BACKGROUND

Vygotsky's social constructivist theory of learning recognises the important role that social interaction plays in the development of thinking. When students are provided with opportunities to practice their reasoning through discussions which do not have an immediate focus on correct answers, they learn better (Chapin, O'Connor & Anderson, 2003). Studies of mathematics classrooms (Hoffer, 2012; Wagganer, 2015; Walshaw & Anthony, 2008) have shown that engaging students in meaningful discourse is key to deepening student learning and understanding.

However, while many teachers acknowledge the value of classroom talk, the enactment of productive talk in the mathematics classroom is challenging (Koay, 2016). Students who are accustomed to the Initiate-Respond-Evaluate (IRE) pattern of interaction (Cazden, 2001), tend to respond to teacher questioning with short answers. Researchers have proposed that teachers move away from this pattern of interaction through the use of talk moves (Michaels & O'Connor, 2012; Zwiers & Crawford, 2011) to orchestrate discourse. Talk moves are strategic teacher moves intended to encourage student participation in the classroom in respectful and academically productive ways (Michaels & O'Connor, 2012).

The teacher talk moves used in this inquiry were adapted from the work of Zwiers and Crawford (2011) and Michaels and O'Connor (2012). Focus areas for teacher talk and related examples of talk moves are shown in Figure 1, as well as sentence frames that teachers can use for prompting students.

| Focus Area | Talk Move | Frames for prompting |
|---|---|---|
| *Voice and clarify a student's idea* | Re-voice for verification | So you're saying that…? |
| *Listen closely to another student* | Ask a student to restate another student's contribution | What do you think X is saying? |
| *Deepen a student's reasoning* | Probe for reasoning or evidence | How did you arrive at that conclusion? |
| *Engage with another's reasoning* | Elicit a student's view on another student's idea | Do you agree or disagree with what X has said? Why? |

Figure 1. Focus areas for teacher talk and related talk moves, with example sentence frames that teachers can use to prompt students.

## PROCEDURE

As an Effective Communication Champion at a Secondary school participating in the Whole School Approach to Effective Communication (WSA-EC) in English programme, the teacher had learnt about teacher talk moves from *Opening Up Talk for Learning in Subject Classrooms*, a professional learning course conducted by ELIS. She wanted her students to extend their verbal responses and articulate their mathematical reasoning more explicitly using precise mathematical language.

The teacher explored ways of using talk moves to achieve this aim by participating in a teacher inquiry cycle (see Figure 2). The ELIS consultants recommended this iterative process and engaged the teacher in reflections on her lessons.

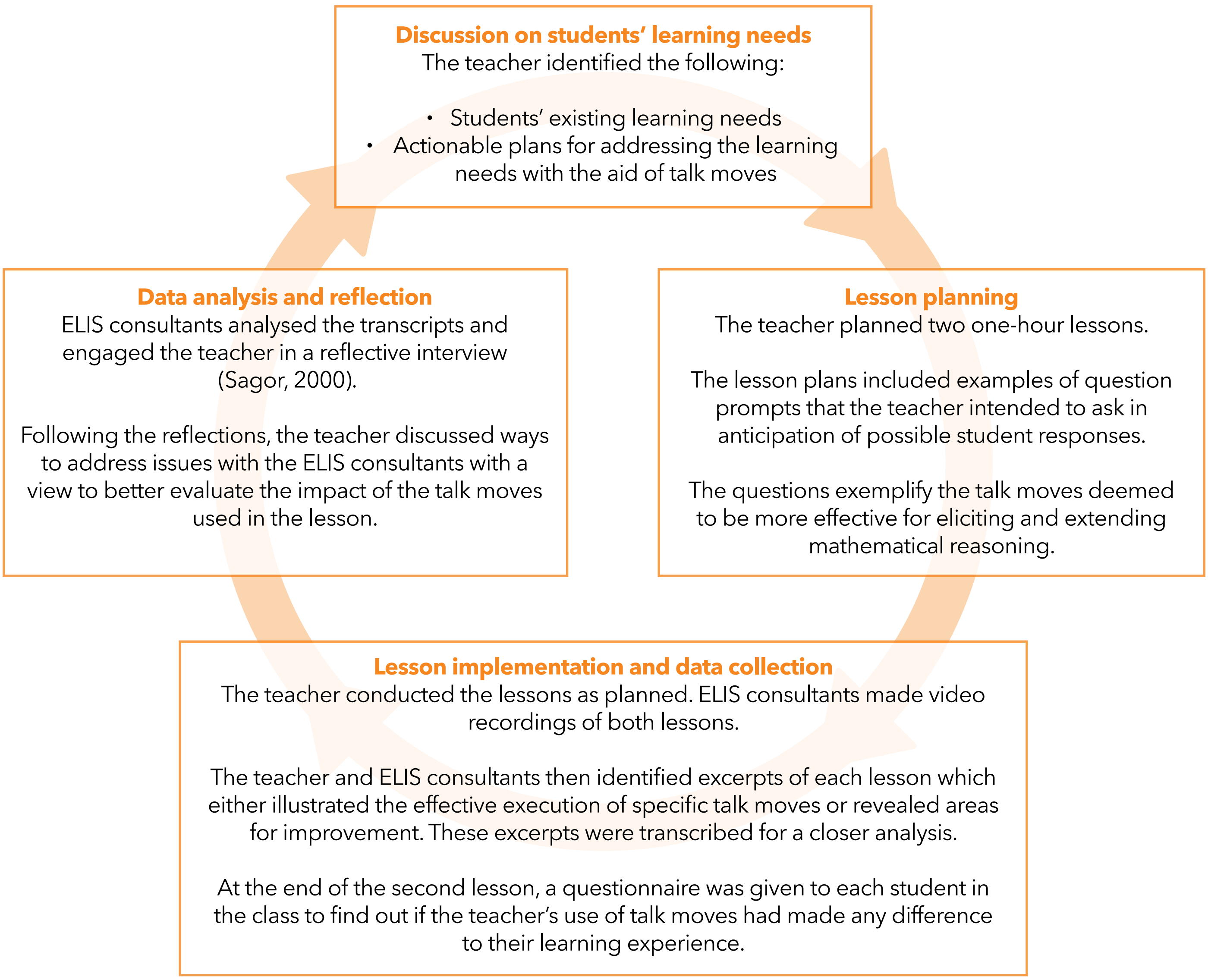



Figure 2. The Teacher Inquiry Cycle (adapted from the 'Teacher Inquiry and Knowledge Building Cycle', Timperley, Wilson, Barrar, and Fung, 2007).

The inquiry project involved 23 Secondary One Normal (Academic) students in a co-educational school. The teacher co-planned two lessons with the Mathematics Head of Department. The first lesson on algebra (Lesson 1) was carried out in Term 2 in 2017, while a second one on parallelograms (Lesson 2) was carried out in Term 4, about four months after the first lesson. In the interval between the first and second inquiry lessons, the teacher continued to use talk moves for selected academic discussions in some of her mathematics lessons with the same class of students.

In Lesson 1, the teacher introduced the topic of algebra to the students. She prepared a series of mathematical tasks and carried out a whole class productive academic discussion using selected talk moves to help students articulate their thinking for doing the tasks. One of the tasks that was used to initiate an academic discussion for this lesson is shown in Figure 3.

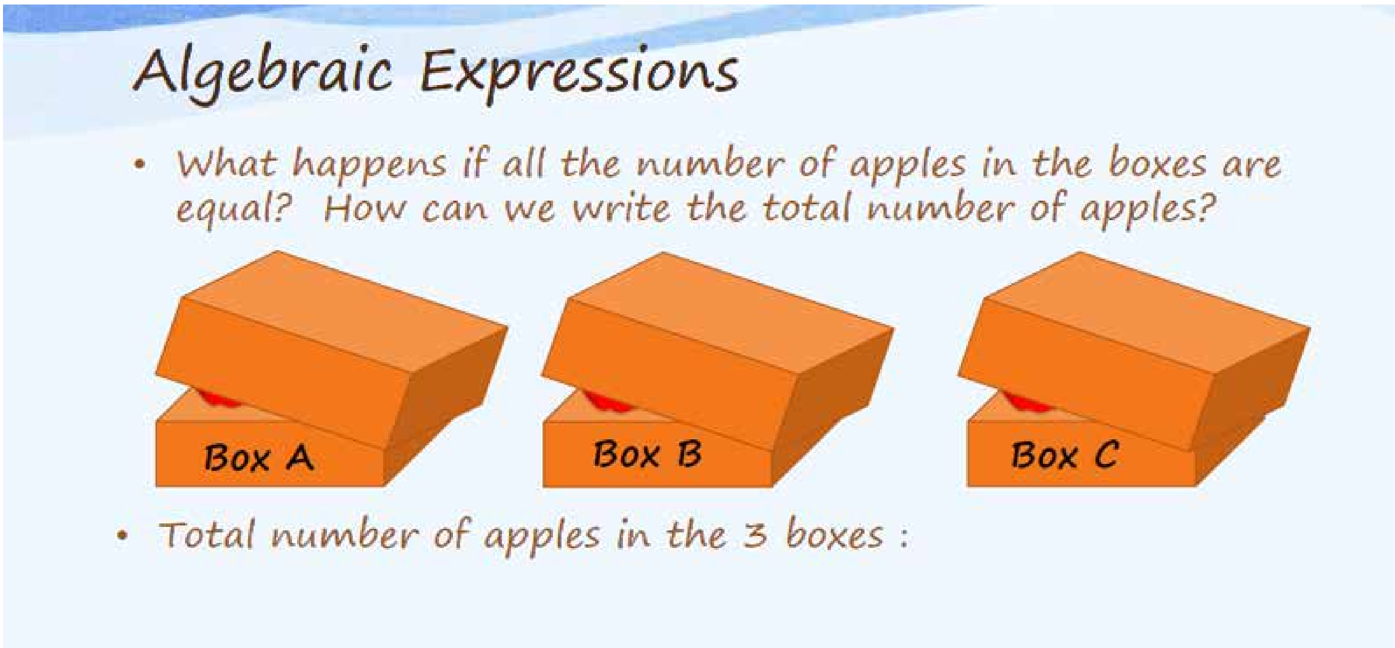



Figure 3. The mathematical task for Lesson 1.

Her purpose was to help students be able to use variables to represent the number of apples in the boxes. For example, students would be able to say, "Let the number of apples in Box C be *x*". She also wanted to ensure that her students could move from using everyday language to using the correct mathematical terms. For example, instead of "three plus five plus *something*", students would be able to say, "three plus five plus *x*".

To achieve this purpose, the teacher planned several question prompts for talk moves that would help students to articulate their own reasoning or engage with their peers' reasoning. She also anticipated student responses to those questions and planned follow-up questions for those anticipated responses, as shown in the excerpt from the teacher's lesson plan for Lesson 1 below:

| | |
|---|---|
| Teacher's question | So how many apples are there in the three boxes? |
| Anticipated response | Three plus five plus eight. |
| Teacher's question | Consider now if I do not know how many apples there are in Box 3. How can I find the total number of apples? |
| Anticipated response | Three plus five plus something. |
| Teacher's question | What is this 'something'? |
| Anticipated response | The number of apples in Box 3. |
| Teacher's question | Is there another way of writing the number of apples in Box 3? |

In Lesson 2, the teacher introduced the topic of parallelograms. As she wanted to provide students with more opportunities to articulate justifications for their reasoning, she designed the task shown in Figure 4.

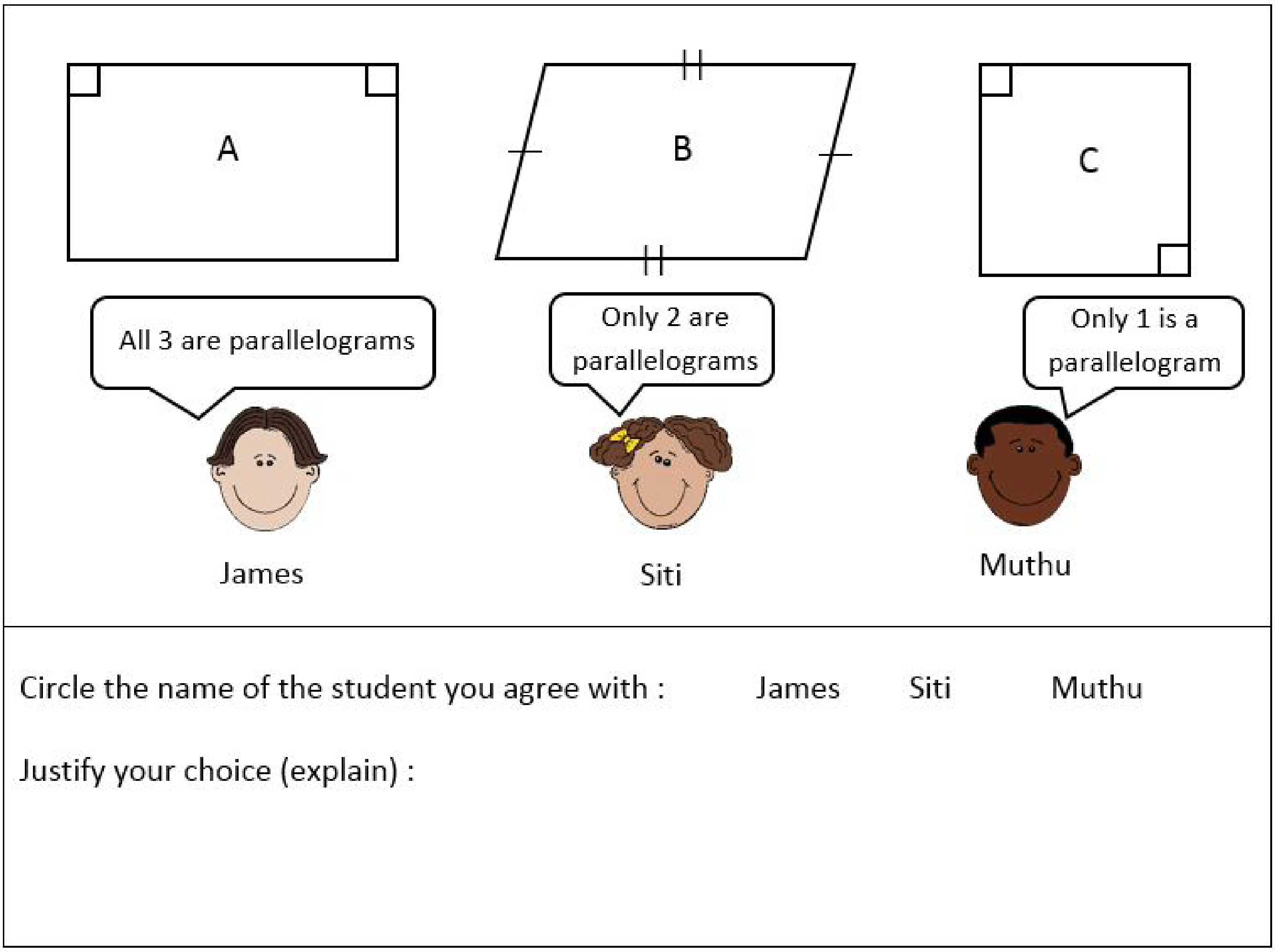



Figure 4. The mathematical task for Lesson 2.

This task required students to decide whether a rectangle and a square could be geometrically classified as parallelograms. To do this, students needed to be familiar with the properties of parallelograms, so that they could justify their responses to the prompt posed in the task shown in Figure 4.

The students were given time to discuss their responses in pairs to the task in Figure 4, before the teacher conducted a whole class productive academic discussion with them. She used the questions she had planned and the anticipated student responses, both of which are shown in the excerpt from the teacher's lesson plan for Lesson 2 below:

| | |
|---|---|
| Teacher | Why do you choose this statement? |
| Anticipated response | Because a parallelogram is a slanted rectangle and there is only one shape that is a slanted rectangle. |
| Teacher's question | Does anyone have a different choice? |
| Anticipated response | All three are parallelograms |
| Teacher's question | Can you explain? |
| Anticipated responses | A parallelogram must have parallel lines. / All three figures have two pairs of parallel lines. |

## FINDINGS

An analysis of the lesson transcripts from the first lesson on algebra showed how the use of talk moves to facilitate productive academic discussions had enabled the teacher to identify underlying student misconceptions, which she could subsequently address in the next lesson. In lesson 2 which was on parallelograms, she further discovered how the use of talk moves could help to reveal gaps in students' subject language. She also found that using talk moves enabled her students to engage in longer stretches of discourse to articulate their mathematical reasoning and created more opportunities for the co-construction of meaning.

### REVEALING STUDENTS' MISCONCEPTIONS

Figure 5 illustrates how the teacher's use of the talk move 'Elicit a student's view on another student's idea' helped to reveal a student misconception that 'three times *x*' could also be written as '*x* to the power of three'. By eliciting a student's view on another student's idea, the teacher was able to draw on S3's correct response to address S2's misconception.

| Speaker | Lesson Transcript | Talk Moves |
|---|---|---|
| Teacher | What happens if all the number of apples in the boxes are equal, how can you write the total number of apples now? | |
| Student 1 | So it means three times something. | |
| Teacher | If I let the number of apples be *x*, it becomes three times *x*. Any other way of writing three times *x*? | *Elicit a student's view on another student's idea* |
| Student 2 | *x* to the power of three. | |
| Students | No (chorus response) | |
| Teacher | *x* to the power of three. Okay, what does *x* to the power of three mean? Yes, S3? | *Elicit a student's view on another student's idea* |
| Student 3 | It means *x* times *x* times *x*. | |
| Teacher | But if I have *x* apples, *x* apples, *x* apples, to find the total you have to? | |
| Student 1 | *x* plus *x* plus *x*. | |
| Teacher | Yes. It's *x* plus *x* plus *x*. So *x* to the power of three is not the same as *x* plus *x* plus *x*. | |

Figure 5. Excerpt of a transcript from Lesson 1 on algebra, annotated to show how talk moves can help to reveal misconceptions.

After reflecting on her use of talk moves in Lesson 1, the teacher realised there were instances when she had paraphrased students' responses to consolidate the discussion. In hindsight, she felt that she could have allowed her students to consolidate the learning after they had built on each other's responses. For example, after Student 1 gave the correct response of "*x* plus *x* plus *x*", she could have asked Student 2 if he still thought that three times *x* could be written as *x* to the power of three, as a way of checking for understanding.

Nonetheless, the discussion did alert her to S2's (and possibly other students') misconception, which she was then able to address in the next lesson.

## REVEALING GAPS IN STUDENTS' SUBJECT LANGUAGE

In Lesson 2, the teacher decided to provide more opportunities for students to talk by using the talk moves: "build on one another's responses" and "restate another student's contribution". In doing this, she was able to identify her students' learning gaps, in terms of subject language fluency (see Figure 6). For example, some students struggled to use the correct mathematical terms such as "opposite sides of a parallelogram" and "a pair of parallel lines", using "this side and that side" and "a parallel line" instead.

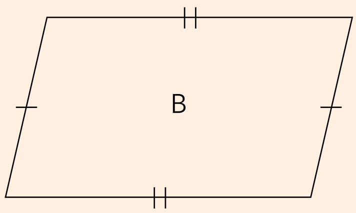
| Speaker | Lesson Transcript | Talk Moves |
|---|---|---|
| Teacher | Okay, your partner wants to say something. | |
| Student 1 | There is a line because… right, the line shows that both of the lengths are the same. | |
| Teacher | S2, would you like to restate what they have just said earlier? | *Ask a student to restate another student's contribution* |
| Student 2 | So they said, not two sides are equal, not like this one, lah. Must be like, one-two, then one-two (*motioning with hands*). I don't know the words, lah. | |
| Teacher | It's okay. Can you explain, or would like to come up here and show me what you are trying to say?<br>*(Pause: student does not respond)* | |
| Teacher | Or maybe you would like to stand up and tell them what you mean? | |
| Student 2 | Okay, you see here, for B right, you see there is one line here, and one line here, and two lines here, and two lines here (*points to figure B on his worksheet, as shown below*). So if the thing is like, two sides are slanted with, so... that's why they say it is slanted.<br><br> | |

Figure 6. Excerpt of a transcript from the lesson on parallelograms, annotated to show how talk moves can help to reveal students' learning gaps.

### CREATING OPPORTUNITIES FOR EXTENDED DISCOURSE AND CO-CONSTRUCTION OF MEANING

In addition to revealing gaps in students' subject language, the teacher observed that her students had become more comfortable engaging in longer stretches of discourse in Lesson 2. At the start of the lesson transcript shown in Figure 7, the teacher was trying to probe students' understanding of the mathematical symbol for equal sides. Student 1's response to her question showed that he had mistakenly confused the single and double strokes of the line in shape B (refer to Figure 3) to mean that the opposite sides of the parallelogram were parallel, when in fact that symbol meant that the opposite sides are equal. However, rather than correct S1 immediately, the teacher used the talk moves: re-voice for verification, elicit a student's view on another student's idea, and seek clarification. This provided another student, S3, with the opportunity to extend his reasoning, although he still lacked adequate subject language while doing so.

| Speaker | Lesson Transcript | Talk Moves |
|---|---|---|
| Teacher | Okay, would anyone like to explain what does these two 'lines' mean? Uh, S3, could I have you explain? | |
| Student 1 | Parallel. | |
| Teacher | That line means parallel? | *Re-voice for verification* |
| Student 1 | It's like, equal sides. | |
| Teacher | Okay, anyone disagree? | *Elicit a student's view on another student's idea* |
| Student 2 | I agree with S1. | |
| Student 3 | I would like to elaborate, because like, the line right… you see that one got two lines, but this one got one line. So the two lines and one line, will show which one… there is the specific one that is the same. | |
| Teacher | When you say that it is the same, what do you mean? | *Seek clarification* |
| Student 3 | Can I show? (*Student goes up to the white screen*)<br>Uh, you see this is two lines right? (*Points to the two dashes*). So for this certain length right, the certain length will be the same for the one with two lines, so this has two lines, so we will know that this two will be the same. But this has one line, and the other has one line, so this two will be the same. | |

Figure 7. Excerpt of a transcript from the lesson on parallelograms, annotated to show how talk moves created opportunities for extended discourse.

The excerpt from the lesson transcript in Figure 8 shows how the teacher engaged the students in a productive discussion through a range of talk moves, and helped her class to arrive at a shared understanding of certain mathematical concepts. Through the discussion, she helped the students reach the conclusion that if two lines were equal, it did not necessarily mean that they would be parallel. Similarly, if two lines were parallel, they did not necessarily have to be equal in length.

| Speaker | Lesson Transcript | Talk Moves |
|---|---|---|
| Student 4 | Can I elaborate? Because, you see, if for example, this is 5cm, this would mean that this is also 5 cm. And if this is 6cm, this would also mean that this is 6cm. | |
| Teacher | Okay. So S5, would you like to put it in simple form? | |
| Student 5 | That means the lines right, are the, are the… they are parallel to each other. The lines are parallel to each other. That means they are equal. Same as a rectangle. | |
| Teacher | Okay, so S5 said that, let me repeat what S5 said okay? | *Re-voice for verification* |
| Teacher | So S5 was saying that, because there are two lines here, it indicated that the length is the same… which means, that they are parallel to each other? | |
| Student 6 | No! | |
| Teacher | Okay, S6 disagrees. S6, can you explain or say why is it that you disagree? | *Elicit a student's view on another student's idea* |
| Student 6 | Because parallel, no matter how long is it, or how short is it, it's still parallel. It's the direction of the line. | |
| Student 7 | It will never meet. | |
| Student 6 | Yup. | |

Figure 8. Excerpt of a transcript from the lesson on parallelograms, annotated to show how talk moves created opportunities for the co-construction of meaning.

Reflecting on her practice in the second lesson, the mathematics teacher felt that she could have used some scaffolding strategies to help students recall the appropriate mathematical vocabulary and symbols before she carried out the academic discussion using talk moves. In that way, students would have been better equipped to build on each other's mathematical reasoning using the appropriate mathematical language. She noted in her reflection:

> "I could include content vocabulary on the board or flipchart so that they can use the proper subject language to express their views and reasoning."

## DISCUSSION

Participating in the inquiry helped deepen the teacher's understanding of how the effective use of talk moves depended on adequate planning of questions, anticipating student responses and planning of follow up questions to those responses. The teacher also became more aware of the need to withhold any immediate judgment of students' answers so as to allow time for students to process what they were learning through engaging with each other's reasoning.

Some challenges were also identified. Although the teacher had anticipated students' potential responses during the lesson planning stage, she encountered moments when students would respond in an unexpected manner. She had to improvise on the spot to make sense of what they were trying to articulate before deciding on her next instructional move. The teacher's experience aligns with Chapin, O'Connor and Anderson's (2003) observation that "part of the cycle of introducing productive talk . . . necessarily involves improvisation and responding in the moment" (p.42).

The teacher realised that expressing mathematical notions using precise mathematical language remained a challenging task for students when they engaged in mathematical discussions in the second lesson. As a result, the ELIS consultants and the teacher developed a new inquiry focus: What language scaffolds can be integrated with classroom talk and instructional materials to support students' learning?

The results from the questionnaire administered after Lesson 2 showed that 86.7% of the students felt that the teacher's approach to posing questions during academic discussions gave them more opportunities to verbalise their thinking and build on their peers' responses. The following reasons provided by students illustrate how the teacher's questioning approach using talk moves had enhanced their learning:

- better understanding of concepts being taught
- opportunities to clarify what they did not understand
- gaining access to peers' thinking facilitated the learning process

Heartened by the results of this inquiry, the teacher plans to continue incorporating the use of talk moves in her mathematics classes and to encourage more of her colleagues to do likewise.

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