Foreword

To help our students to succeed, we have to focus on our teachers. To a layman, this statement may seem counter-intuitive. However, as professionals, we know that our continual growth in knowledge and skills is key if we want to make a sustained impact on how well our students learn.

For a while now, our fraternity has focused on growing and leveraging teacher leadership to enhance the professionalism of the fraternity. In this connection, I am very glad to know that teacher leadership is alive, well, and vibrant in the East Zone schools. Whether formally appointed or otherwise, the colleagues who have contributed to the 23 carefully selected articles in this third issue of The Art and Craft of Teaching have demonstrated teacher leadership. What they have shared in their articles has been enacted, refined, and reflected upon in learning spaces across at least 18 schools in the East Zone. I am sure there will be some gems for all of us to pick up from this collection as we seek to enhance our professional practices.

In documenting their learning, our colleagues have codified what would otherwise have remained tacit in their minds and practices. Such codification is critical to knowledge transfer between members of the same profession and the enhancement of professional practices. Last year, the Singapore Teaching Practice (STP) was introduced to the fraternity as our very own model for teaching and learning. The STP codifies our shared curricular beliefs, pedagogical practices, and knowledge bases. It makes explicit the professional basis for what we think, say, and do as teachers. It also provides a common language for us to dialogue on professional matters as teachers in Singapore. I hope that, as part of our professional learning journey, we will continue to codify and share our knowledge and practices, and take time to have deep, meaningful conversations with each other.

I would also like to commend Dunman High School for serving as the East Zone Centre of Excellence for Teaching and Learning (EZ COE T&L) since 2011. As a learning hub for teachers, it has catalysed the development of a learning ecosystem wherein colleagues can engage in collaborative and continuous learning. As the zone’s watering hole for learning, it organises and hosts Professional Learning Day and other learning platforms in the school for teachers with different learning goals and prior experience. This publication is also made possible because of the strong support of the school’s leaders and the COE team.

It is indeed wonderful to be in a profession where learning is part and parcel of what we do, and not something of an afterthought. I encourage you to consider this publication as a gift from colleagues who want the best for us, invest time in reading the articles mindfully, and apply adaptively what is relevant to your interactions with your students.

Chan Yew Wooi
Director, Professional Development
Academy of Singapore Teachers
Students don’t care how much we know, until they know how much we care. But how do students know whether, how, and why we care for them? A powerful way would be to ask questions about what affects our students’ learning, and how we can change and innovate our teaching to meet their needs. Such inquiry may be labelled ‘classroom research’, or ‘action research’, or ‘teaching innovation’. Regardless, what matters most is our students know that we do not take their learning for granted, and that we care enough to systematically inquire about how and how well they are learning.

This collection of educational research is wonderful evidence of teachers in the East Zone taking great care to innovate and to inquire into issues and ideas that have great potential for enhancing students’ efficacy and enjoyment of learning. Through systematic inquiry of students’ needs and careful incubation of considered interventions, each article is an invitation for readers to rediscover the joys of teaching, and to exemplify learning and inquiry for our students and colleagues.

Ponder on the motivation(s) that prompted the teachers to initiate their studies – was it something they observed in their classes, or a comment or suggestion made by their students, or intuition that their learners needed something different? Then think about the effect each study had on the students – were they glad to be privy to action research, and did such involvement give them a ringside seat to witnessing exemplary and impactful inquiry?

Research may be described simply as systematic inquiry made public. When students know, through our research, that we care for them and their learning, then all the questions we ask and pursue become inquiry made impactful.

I commend these articles for careful reading and reflection. Be encouraged, remain curious, and give yourself and your students every chance to rediscover the joy of teaching and learning.

Associate Professor Kelvin Tan
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In a neighbourhood primary school setting, students may walk through the classroom doors wide-eyed and clueless about the wide vista of English language learning. In the area of writing, in particular, our primary school students grapple with developing the story line as well as crafting interesting plots and characters. This is all predominantly due to the students not reading extensively. The average student lacks the motivation to read beyond his or her textbooks.

Today, teachers face the challenge of weaning our students away from the ubiquitous Mighty Monster – the games that invade these children’s gadgets. To them, reading appears antiquated and is a bothersome activity mandated by adults. This is of grave concern to teachers as we all know how important the ability to read and write is to the future success of those we teach. If our students remain reluctant to read, how will they then compete with others in the global arena? With this in mind, a group of Primary Four teachers embarked on a project to cultivate the love of reading in our students via a literature package based on E.B. White’s wonderful book, Charlotte’s Web.

According to Dr Stephen D. Krashen (Professor Emeritus of Education, University of Southern California), an internationally known researcher and author of The Power of Reading, the way to becoming a good writer is to read. “Reading is a powerful means of developing literacy, or developing reading comprehension ability, writing style, vocabulary, grammar, and spelling.” (p. 23). Krashen advocates free voluntary reading i.e. reading whatever you want to. This also means that Krashen has no qualms about what students read; even comics and teen romances are acceptable. This is similar to the Silent Reading Programme in many Singapore schools. However, Krashen notes that free voluntary reading merely provides a “foundation so that higher levels of proficiency may be reached” (p. 1). So, mere reading is not enough. Krashen says that assigned reading by teachers must necessarily complement this.

Our paper essentially focuses on Krashen’s assigned reading theory. If we could motivate the students to read a story accompanied by an enriching discussion and some non-academic tasks, their command of language would show a considerable improvement alongside a better understanding of the plot and the characters in the story. In the long term, this would mean richer, more nuanced writing.
Why choose *Charlotte’s Web*? In 2000, *Publishers Weekly* listed the book as the best-selling children’s paperback of all time. E. B. White’s writing is known for its meticulous detail in the creation of the setting and in the development of characters. It is also rich in description, emotion, and life events. The book revolves around the main character, Charlotte, a wise spider, who befriends a little pig, Wilbur. One cannot help but fall in love with Charlotte. We decided to let students have fun creating Charlotte with a variety of items (see Table 1). The process of creating a spider lent itself well to learning imperatives such as ‘squeeze’, ‘stick’, ‘twist’, etc. We also noticed that students, especially low-progress learners, were able to enjoy this activity in a non-threatening environment. It was observed that every child was engaged and looked forward to the literature lessons.

As a motivational booster for our group of Primary Four students, we planned some fun-filled, hands-on experiences for the twenty-two chapters of *Charlotte’s Web*.

### Table 1: Instructions for Making ‘Charlotte’

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<th>Step</th>
<th>Instruction</th>
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<tr>
<td>1</td>
<td>Squeeze some glue onto both googly eyes.</td>
</tr>
<tr>
<td>2</td>
<td>Stick both googly eyes onto the pom pom</td>
</tr>
<tr>
<td>3</td>
<td>Press the pom pom and googly eyes together.</td>
</tr>
<tr>
<td>4</td>
<td>Pick up all four pipe cleaners.</td>
</tr>
<tr>
<td>5</td>
<td>Twist them together in the middle.</td>
</tr>
<tr>
<td>6</td>
<td>Squeeze some glue onto the pipe cleaners.</td>
</tr>
<tr>
<td>7</td>
<td>Stick the pom pom to the pipe cleaners.</td>
</tr>
<tr>
<td>8</td>
<td>Press the pipe cleaners and the pom pom together.</td>
</tr>
<tr>
<td>9</td>
<td>Arrange the legs neatly.</td>
</tr>
<tr>
<td>10</td>
<td>Bend the legs so the spider can stand.</td>
</tr>
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</table>

To sustain our Primary Four students’ interest in reading, there was a need to plan and expose them to various activities in our lessons. The literature package spanned ten weeks. As listed in Table 2, the students would be exposed to and engaged in a variety of activities and stimuli such as weekly quizzes, Special Friend certificates, making pop-up cards, and worksheets in various forms. Our ten-year-olds were thus guided to use higher-order thinking skills in these engaging yet meaningful tasks.

We believed that the activities and accompanying worksheets would encourage our students to understand the plot of the story and glean some insight into character traits as the characters evolved at different junctures as the story unfolded.
In deciding the sequence of the lessons, we sought to avoid the usual pattern of reading, followed by discussion, then the completion of a worksheet. That would be too predictable, hence leading to boredom. Instead, students found that delightful quizzes awaited them. These quizzes were fun to do, yet tested their understanding of the chapters they had just read. As an IT alternative, a teacher could utilise the study app, Quizzlet. The benefit of using quizzes is that they test memory, recall, and basic reasoning. Weimer (2017) states that students were “more motivated to come to class prepared when the course included quizzes”.

Noticeably, the quizzes helped our students understand the chapters read as they listened to their friends’ views on a particular event.

The following outlines each lesson in a nutshell (with resources used):
- Read chapter(s) assigned
- Discuss (in pairs or as a class) the main events of the story (see Figure 1)
- Quiz (see Figure 2)
- Activity (see Figure 3)

### Table 2: Overview of Activities

<table>
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<tr>
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<td>10</td>
<td>Quiz + Word Wizard WS</td>
</tr>
<tr>
<td>II</td>
<td>3</td>
<td>Quiz + Worksheet 1</td>
<td>VII</td>
<td>11 &amp; 12</td>
<td>Quiz + Worksheet 4 (HA)</td>
</tr>
<tr>
<td>III</td>
<td>4 &amp; 5</td>
<td>Quiz + Special Friend Certificate</td>
<td>VIII</td>
<td>13, 14 &amp; 15</td>
<td>Quiz + Worksheet 5 (HA)</td>
</tr>
<tr>
<td>IV</td>
<td>6 &amp; 7</td>
<td>Quiz + Worksheet 2</td>
<td>IX</td>
<td>16, 17 &amp; 18</td>
<td>Quiz + Worksheet 6</td>
</tr>
<tr>
<td>V</td>
<td>8 &amp; 9</td>
<td>Quiz + Worksheet 3</td>
<td>X</td>
<td>19, 20, 21 &amp; 22</td>
<td>Quiz + Worksheet 7 + Pop-up card</td>
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**SEQUENCE OF LESSONS**

Duration: 10 weeks

Table 2: Overview of Activities

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<td>X</td>
<td>19, 20, 21 &amp; 22</td>
<td>Quiz + Worksheet 7 + Pop-up card</td>
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**Figure 1: The Main Events**

**Figure 2: Weekly Quizzes**

**Figure 3: Artefacts from Hands-on Activities**
As the weeks went by, our teachers perceived a growing interest in the story among the students. Thus, we decided to incorporate the tasks into their holistic assessment. We selected meaningful passages from *Charlotte’s Web* (see Figure 4) and utilised them as oral reading tasks. A set of rubrics was drawn up to gauge our students’ reading fluency.

For the Main Events worksheet (Figure 5a), students worked on listing the various events which occurred in the assigned reading passage. The Character Traits worksheet (Figure 5b) helped students better understand the characters as they evolved with the story. The Special Friend Certificate (Figure 5c) tapped on the Social and Emotional Learning (SEL) aspect of empathy between the characters.

Looking back over the ten weeks, it was clear that students were motivated to read the story because of the varied activities. They were also better able to express their thoughts on and feelings about the various characters they encountered. Students were highly engaged as they enjoyed the lessons and looked forward to the next one.
This project culminated in a Curriculum Experience Day where the students were immersed in exciting and innovative activities which stimulated creative thinking (see Figure 6).

We ascertained that reading is one of the most effective ways for language learners, especially the weaker learners, to acquire language skills in context. With the literature package, students gained confidence when they realised that the activities and assignments were not part of a summative assessment. With this assurance, students participated actively in post-reading discussions and hands-on activities, and were motivated to read. We believe that our students have become proficient readers, which will positively impact their writing skills as they begin to develop good plots and describe characters well in their own writing.


June Lee is an experienced English language teacher in Bedok Green Primary School. She enjoys infusing fun activities into her lessons to enrich her students’ learning experience of the language. She believes that it is important to have a good grasp of the language in order to communicate effectively.

Jacinta Gomes teaches English in Bedok Green Primary School. She has a wide range of interests, including drama and debating. In particular, she is keen on building her repertoire of drama skills. She firmly believes in the importance of language skills in the furtherance of both academics and co-curricular activities.
Group Work — Classroom Discussion or just Busy Work?

ABSTRACT

Group discussion can be an effective strategy for learning on the premise that expectations are clear for both teachers and learners, and explicit training of skills has been done to bring about purposeful talk. Unless these are in place, the so-called discussion will be a mere waste of learning time and resources. However, done properly, students will experience both cognitive and metacognitive processes that will have long-term impact on their learning. Specifically, discussion can hone students’ speaking skills and develop them into articulate and confident speakers.

INTRODUCTION

Speaking is one of the key skills required for our students to be effective communicators, particularly in the 21st century. The changing global landscape calls for confident speakers who are able to voice their opinions, engage in discussions, and present their ideas according to different purposes, audiences, and contexts. Historically, the emphasis on examination results has led most teachers to focus on reading, writing, and grammar at the expense of speaking and listening, which only receive attention as the oral and listening examinations draw near. This ‘drill and practice to the test’ approach, however, cannot be equated to the teaching of the skills. As Singapore advances further into the 21st century, education also takes a deeper look into the curriculum that will prepare our students for the future. The ‘teach to the test’ methodology will not place our students in a favourable position against their global competitors. As English still remains the lingua franca of the global economy, teachers must look into a holistic pedagogical approach to the teaching and learning of English.

RATIONALE FOR SMALL-GROUP DISCUSSIONS

In honing students’ speaking skills to develop fluency, it is crucial to give students sufficient practice. When students participate in small-group discussion, a type of problem-solving task in itself, they are enabled to interact with one another verbally to exchange ideas and come to a consensus. They are given the opportunity to communicate on authentic issues and practise their speaking skills as they develop speech function and interaction management skills (Goh, 2007, p. 38). In small-group discussions, the teacher assigns interactional status to students to give them more participation rights in conversations (Kasper, 2001). It is through ample opportunity and adequate practice that students gain confidence to express their thoughts fluently, and are thus able to build their speaking competency.

In building this fluency, we have adapted a group activity from Goh (2007, p. 44) with the intended purpose of raising students’ awareness of and level of competence in using
good speaking and listening skills for an in-depth discussion that emphasises the speaking component (Appendix A). The observer role has been included so the whole process can be transcribed, which will then act as feedback on students’ learning for the teachers. In this way, no student is excluded as the observer reaps the benefits of the group discussion to present the summary at the end of the discussion process.

To ensure that the discussion is fruitful and effectively develops students’ speaking skills, a number of factors need to be in place. Firstly, teachers need to effectively communicate the expectations and the learning objectives to every student. This can only be successfully achieved when teachers are able to establish an ‘open’ learning context instead of a ‘closed’ one, where students are aware that the focus is on engagement in thinking and speaking, and not on the outcome of the talk (Cordon, 2000). Secondly, teachers must give clear instructions, as this can influence students’ performance. It is not necessarily the nature of the task that determines the interaction, but students’ conceptions of the ground rules (Barnes, 2008). Without explicit ground rules, talk may become shallow and superficial. Finally, students’ limited knowledge and abilities may impede successful discussion. Thus, teachers need to ensure that the topic selected for the discussion will give students the opportunity to engage in a purposeful and fruitful discussion. At this point, teachers may wish to apply Vygotsky’s Zone of Proximal Development (ZPD).

**SCAFFOLDING**

Information gaps need to be plugged via scaffolding to ensure equal opportunity for all students, so that everyone can contribute actively to the discussion. The ZPD refers to the critical point at which learners, with their current knowledge and level of competence, require support from an expert if they are to develop further. In the classroom, the teacher is the expert who provides scaffolded instruction and guidance to develop students’ language competency. Since students face difficulties in producing well-developed responses due to a lack of ideas, scaffolding can be used in the pre-activity. In the sample secondary school lesson plan (Appendix A), the teacher activates the students’ prior knowledge by getting them to make associations between ‘tigers’ and ‘mothers’ before watching the video. Similarly, in the sample primary school lesson plan, the class is given an article to read prior to watching the video. In both lessons, pre-viewing questions are posed to scaffold students’ understanding of the viewing and comprehension materials that are presented to them. These questions also require students to relate the topic to their own lives in order to tap on their personal experiences for better understanding. The videos serve as a scaffold by providing relevant information required for the discussion later on. Students will also find the videos particularly entertaining, and their authenticity will pique the students’ interest for better engagement.

Providing students with the PEEL (Point, Elaboration, Explanation, Link; secondary level) or PEEE (Point, Elaborate, Explain, relate to Experience; primary level) structure will help them to craft coherent, well-developed, and persuasive verbal responses. This is especially useful when students are stuck and unsure how to continue. Hopefully, with more practice, students will be able to achieve metacognition by consciously employing PEEL or PEEE as the appropriate strategy with which to frame their responses to convey and construct meaning during interactions. Given time for pre-task planning, using PEEL or PEEE aids spoken production with regard to fluency and complexity, with accuracy taking a backseat (Yuan & Ellis, 2003).

It must be acknowledged that, since the activity is task-based, more emphasis is placed on fluency and less on accuracy. This is due to the communicative nature of tasks (Goh & Burns, 2012). Fluency entails communicating meaning effectively with few pauses and hesitations. Yet, one ironically requires a reasonable command of grammar, an ample vocabulary, and good pronunciation to be clear and intelligible (Goh, 2007, p. 12). Hence, lessons that are grammar-focused and pronunciation-focused must also be carried out for students to be effective communicators, either as a follow-up to this lesson or prior to it. Furthermore, awareness of discourse intonation features, such as the use of falling and rising tones, and changes in pitch, is important as it affects the communicative value of speech. The ability to grasp intonation helps students overcome grammatical misunderstandings of utterances, decode the stream of speech more effectively, and reproduce the appropriate intonation in their verbal responses for conversation management (Chapman, 2007). Therefore, attention should also be paid to the teaching of intonation to develop students’ competency in communication in the real world as well.

Additionally, while students are given a structure, they are not equipped with formulaic language units, multi-word strings or frames which are stored for retrieval in long-term memory for spontaneous speech to occur in real-life
discourse (Miller & Weinert, 1998; Skehan, 1998; Weinert, 1995; Wray & Perkins, 2000). Possessing formulaic language units, called ‘lexical phrases’ by Nattinger and DeCarrico (1992), allows students to utilise patterns of lexical items and phrases to frame and string sentences to increase speed of speech. Consistent activation leads to a learned, automatic process over time when these are stored as automatized units in memory, which then enables students to achieve speed and pause patterns which characterise fluent speech (Wood, 2001). Therefore, there is a need to give students time in class for regular practice to equip them with formulaic language units, so that they can use formulaic expressions and discourse markers for acknowledging, agreeing, disagreeing, modifying, negotiating, and summarising for effective group discussions. Explicit teaching has to take place, and this activity should only be carried out for students who possess knowledge of formulaic expressions and discourse markers.

**TYPES OF TALK**

The small-group discussion is reminiscent of social monologues, rather than conversations, as students speak extensively on a topic without interruption. This is ideal for reducing students’ anxiety and using class time optimally for more learner talk. For social monologues to be effective, students need to possess grammatical competence and vocabulary related to the topic (Goh, 2007, p. 18). Thus, in this lesson, new vocabulary from the videos and the articles is introduced to the students. One criticism, however, is that social monologues are not realistic, as being able to interrupt others by asking questions to seek clarification happens during authentic conversations.

The quality of the group discussion is a concern as there are different types of talk, with six types of utterances characterising small-group discussions (Barnes & Todd, 1977; Corden, 2000; Mercer, 2000). Undesirable utterances can adversely impact the depth of the discussion and the practice of speaking skills. In cumulative talk, group consensus is reached quickly as it is uncritical and students do not question each other, so little discussion is actually involved. Conversely, in disputational talk, collaboration is scarce or non-existent as it is filled with disagreements since students are assertive when making their individual points. In desultory talk, there is little enthusiasm and student engagement is lacking when their exchanges are random.

To avoid these unwanted utterances, the activity promotes desirable utterances. In reasoned talk, students give their individual views and support them by using PEEL or PEEE. Moreover, hypothetical and exploratory talk is encouraged as students can share different perspectives, depending on the stand they are assigned to, when they explore the topic from various angles for a rich discussion. Finally, evaluative talk occurs during the discussion when students make constructive arguments and critique each other’s ideas during counter-argument. Therefore, students are given the opportunity to participate in exploratory, evaluative and reasoned talk to hone their oracy skills in this small-group discussion.

**TEACHER ASSESSMENT & SELF-ASSESSMENT**

In the post-activity, the students, in both secondary and primary contexts, are given a rubric to evaluate their own performance during the discussion activity through a self-reflection worksheet (Appendix B). This requires students to be aware of their own progress and what is expected of them as speakers (Dawes, Hubbard, & Smith, 2005). When students self-reflect, they better understand themselves as learners, gain more ownership of their own learning, and set independent goals to plan and monitor their own learning. This is reminiscent of the metacognitive process that students should eventually master.

Assessment of student progress is integral to any lesson for teachers to obtain feedback on their students’ learning. The formative assessment in this lesson means teachers can proceed to give feedback to students on their speaking skills without having the latter undergo the stress of formal summative assessment. With the integration of the formative assessment, teachers can evaluate the effectiveness of their teaching practice by identifying the strengths and weaknesses of using small-group discussions as pedagogy, as well as refine and improve on the lesson (Goh & Burns, 2012). Reflecting on and evaluating one’s practice is essential for teachers’ professional development.
In the course of the lesson, the teacher is relegated to being a facilitator and a silent observer. According to Howe (1990), students’ perceptions of the teacher in a supportive and facilitating role allow them to build a learning context on their own or a ‘climate of reciprocity’. Thus, when students collectively perceive the teacher in a non-evaluative role, the ownership of learning is transferred to them as they engage in collaborative learning through an exchange of diverse and conflicting ideas to create their own learning experience.

CONCLUSION

All in all, in the development of the speaking skill, the aim is for students to be confident communicators, able to engage in purposeful, constructive talk of an exploratory and evaluative nature. A one-off lesson alone is not enough. What is needed to improve students’ oracy in terms of delivery and content is a series of such lessons on varying topics and issues. A systematic approach to the various aspects of speaking development, encompassing accuracy and fluency for students, is required to activate cognitive and metacognitive processes in honing their oracy skills.

REFERENCES


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**ABOUT THE CONTRIBUTORS**

**Rafeah Yahya** has been teaching for 26 years and holds a Master of Education (English Language). A former HOD and now a Lead Teacher, she attended the Teacher Leadership Programme where she continued to hone her craft and pursue her passion for language teaching and learning. Her love of the profession challenges her to dig deeper into her practice and search for meaningful ways to help teachers nurture their students in developing the love for learning the language. She is actively involved in building a strong and holistic EL curriculum with her EL HOD and team of EL teachers. She is also mentoring the cluster Primary School EL Senior Teachers in deepening the pedagogy in writing and oracy.

**Tay Su-Hui Fiona** is currently an Academy Officer in the Professional Development Branch at the Academy of Singapore Teachers. She was previously in Damai Secondary School until June 2017, spreading her love for English Language and Literature for 7 years before deciding to experience another facet of the teaching fraternity. She believes in lifelong learning and constantly seeks to challenge herself. She holds a Master of Education (English Language) and was a nominee for the Inspiring Teacher of English (Leadership Award) 2015. Her interest lies in getting students to be self-directed learners by tapping into metacognition and posing effective questions to facilitate critical thinking. She is also interested in the professional development of others and the self, and is always open to the sharing of new ideas and to collaboration.
Appendix A

Sample Lesson Plan for the Secondary Level

Name of Teacher: Tay Su-Hui Fiona

Duration of lesson: 60 minutes

Class (Level and Stream): Secondary 3 Express

Student Profile

- Students are from an average neighbourhood secondary school with a handful of international students from the ASEAN region in the class.
- For the majority of the students, English is not the predominant language spoken at home.
- Many students are anxious about the conversation component in the oral examination, Spoken Interaction. Difficulties faced by students include suffering from mental block, being tongue-tied, being unable to think on their feet, lacking ideas, lacking elaboration, and the inability to convey ideas using appropriate vocabulary.

Lesson Objectives

Speaking and Representing

- LO3: Plan and present information and ideas for a variety of purposes
- LO4: Use appropriate skills, strategies, and language to convey and construct meaning during interactions

Materials

- Article: ‘Why Chinese Mothers Are Superior’
- Bell
- Worksheet: Reflection on my Speaking Performance

Procedures/ Learning & Teaching Activities

- Pre-activity (20 minutes)

Teacher to write ‘Tiger Mother’ on the board and elicit students’ responses on what they think the term means. Teacher then draws students’ attention to the characteristics of a tiger and a fierce mother to make the connection, and explains to students not all mothers are ‘tiger mothers’ because parents adopt different parenting styles.

Teacher informs students that they are going to watch a video on an Asian mother reprimanding her daughter over her grades in an American diner. As students watch the video, they are to consider the following questions, written on the board:

1) What is the difference between the Asian and Western parenting styles?
2) Which parenting style do you prefer and why?
3) Which parenting style does your mother adopt?

Teacher plays the YouTube video from the beginning to 5:33.

After watching the video, the teacher elicits students’ responses to the 3 questions for a classroom discussion, and clarifies vocabulary words mentioned in the video which students might not be familiar with (i.e. ‘mediocre’).
Teacher explains that this video was sparked by Amy Chua’s book on the Asian parenting style and assigns the article, ‘Why Chinese Mothers are Superior’, to students for a quick read. Teacher is to seize the teachable moment by drawing students’ attention to unfamiliar vocabulary in the text (i.e. ‘stereotypes’, ‘tenacious’, ‘self-indulgent’).

**During Activity (30 minutes)**

**Group Discussion Procedure**

1. Teacher assigns students into groups of 5 for a small-group discussion. Each group has a good mix of stronger and weaker speakers. One student is appointed the observer and the remaining 4 students are designated A, B, C, or D.
2. Give students the topic for discussion: ‘The Asian parenting style is superior to the Western parenting style. Do you agree?’.
3. Teacher reminds students that they are to adopt the acronym PEEL (Point, Elaboration, Explanation, Link), which is also employed in writing expository paragraphs, to craft their verbal responses.
4. Speakers A and C adopt a ‘for’ position, while Speakers B and D adopt the ‘against’ position. The observer is to listen closely, scribe the key points raised by the speakers, and prepare to summarise the whole discussion.
5. Students are given 5 minutes to plan and jot down thoughts prior to the discussion. The observer lists his or her own ideas, too. They may refer to the article for points and ideas.
6. Teacher sets the ground rules: Students are each given 1 minute to speak. Students must speak in full, grammatical sentences. A bell will signal when time is up. Students are not to interrupt when their friends are speaking. All must listen closely and critically.
7. Speaker A begins by giving his or her views. When it is Speaker B’s turn to speak, he or she must continue from Speaker A’s point and produce a counter-argument.
8. After Speaker B has spoken, Speaker C will do the same. And so on, and so forth.
9. Repeat this whole sequence once.
10. After two rounds, the observers in each group are given 2 minutes to wrap up the discussion with a summary of the group’s views.
11. Due to time constraints, selected observers will present their group’s views to the rest of the class. Ideally, all should present.

Teacher may not intervene in any group’s discussion unless absolutely necessary, such as when there is mounting conflict within a group or to probe a weak student.

**Post-activity (10 minutes)**

Teacher concludes the lesson by commending the groups’ efforts and commenting on the points raised during the group discussion after the observers’ presentations.

Teacher distributes the reflection worksheet ([Appendix B](#)) for students to reflect on and rate their speaking performances so as to identify their strengths and areas requiring improvement. Students hand in their reflection worksheets and the group observers’ notes to the teacher.

**Evaluation**

- Assessment for learning occurs when the teacher goes around the class observing students speak during their group discussions.
- The quality and progress of each group’s discussion can also be determined during the presentations by the group observers.
- Textual evidence on the quality of students’ discussions can be gathered from the transcribed group discussions.
- The success of the lesson can also be determined through the students’ reflections on their own performances, which can also be used as a form of needs analysis for future speaking lessons.
Sample Lesson Plan for the Primary Level

Name of Teacher: Azizah Juma’at

Duration of lesson: 60 minutes

Class: Primary 5 Respect

Student Profile

- Students are from a high-progressing class in a government-aided school.
- For the majority of the students, English is the predominant language spoken at home.
- Students are generally outspoken, which requires the teacher to enforce a classroom rule of turn-taking and showing respect. Issues that arise during classroom discussions are a lack of focus on the task, control by a few dominant speakers, and poor management of time.

Lesson Objectives

Speaking and Representing

- LO3: Plan and present information and ideas for a variety of purposes
- LO4: Use appropriate skills, strategies, and language to convey and construct meaning during interactions

Materials

- YouTube Video
- Article: ‘An Unexpected Turn of Event’
- A3 writing paper, butcher paper, story-planning template
- Worksheet: Reflection on my Speaking Performance

Procedure/ Learning & Teaching Activities

- Pre-activity (20 minutes)

Teacher leads the brainstorming on what the phrase ‘unexpected twist of events’ means. Allow students to share their ideas based on their present knowledge and cite possible examples to illustrate their ideas.

Teacher Talk for Effective Questioning:

- What does the phrase ‘unexpected twist of events’ mean?
  [Allow for wait time. Select students who volunteer to provide the possible answers. List the answers on the board.]
- So, based on the answers given, are you able to provide examples of such ‘unexpected twist of events’? Let’s briefly list a few examples.
- Why do you consider these situations ‘unexpected twist of events’? (these examples will reaffirm students’ understanding of the phrase)

Teacher reads the article, ‘An Unexpected Turn of Event’, to students, allowing them to highlight difficult words and/or phrases. Class may discuss these words and/or phrases.

Teacher then allows for a quick buzz with students’ shoulder partners on the initial expectation of the unexpected turn of event in the story. Teacher then gets students to view the video that shows an unexpected twist. After viewing, students’ responses to the event are elicited and discussion unfolds as to how each student feels about it.
• **During Activity (30 minutes)**

**Group Discussion Procedure**

1. Teacher assigns students into groups of 5 for a small-group discussion. Each group has a good mix of stronger and weaker speakers. One student is appointed the observer and the remaining 4 students are designated A, B, C, or D.
2. Give students the topic for discussion: ‘There is never a wrong reaction when things happen unexpectedly. Therefore, we must never fault anyone for making a bad decision at that time. Do you agree?’.
3. Teacher reminds students that they are to use PEEE (Point, Elaborate, Explain, relate to Experience) to help them process and craft their verbal responses.
4. Speakers A and C adopt a ‘for’ position, while Speakers B and D adopt the ‘against’ position. The observer is to listen closely, jot down key points raised by the speakers, and prepare to summarise the discussion.
5. Students are given 5 minutes to plan and jot down their thoughts before the discussion. The observer lists his or her own ideas, too.
6. Teacher then sets the rules: Students are each given 1 minute to speak. Students must speak in full, grammatical sentences. A signal will be given when the time is up. Students are reminded to refrain from interrupting their friends who are speaking. They are reminded to listen closely and critically. Speaker A begins by giving his or her views. When it is Speaker B’s turn to speak, he or she must continue from Speaker A’s point and produce a counter-argument. After Speaker B has spoken, Speaker C will do the same. And so on, and so forth.
7. Repeat this whole sequence once.
8. After the two rounds, the observers in each group are given 2 minutes to wrap up the discussion with a summary of the group’s views.
9. Observers will present their group’s views to the rest of the class. Should time run out before all observers can share, these observers will write down their observations for a gallery walk at the start of the next lesson.

• **Post-activity (10 minutes)**

Teacher concludes the lesson by summarising the points raised and stressing the importance of respecting every view. She then commends the groups for their efforts and comments on the points raised during the group discussion. Teacher also points out to the students that these views can help them when they plan the complication or resolution in their stories in the follow-up activity.

Teacher then distributes the reflection worksheet (Appendix B) for students to reflect on and rate their speaking performances so as to identify their strengths and areas requiring improvement. Students hand in their reflection worksheets and the group observers’ notes to the teacher.

**Evaluation**

- Assessment for learning occurs when the teacher goes around the class observing students speak during their group discussions. The teacher may also wish to videotape the lesson or use audio recording devices so that the teacher can watch or listen to the discussions and transcribe some learning points.
- The quality and progress of each group’s discussion can also be determined during the presentations by the group observers.
- The students’ reflections on their own performances can be used to analyse their speaking success and help target students’ speaking competencies that need practice or more work.
Appendix B: Post-activity Student Reflection (can be used for both Secondary and Primary)

Reflection on my Speaking Performance

<table>
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<tr>
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<tbody>
<tr>
<td><strong>Clarity and Articulation</strong></td>
<td>I spoke clearly throughout the sharing and conveyed meaning effectively.</td>
<td>I spoke clearly most of the time but was sometimes inaudible.</td>
<td>I spoke softly and mumbled. I could not be understood.</td>
<td></td>
</tr>
<tr>
<td><strong>Gestures</strong></td>
<td>I felt relaxed and confident. I was animated and able to use appropriate gestures.</td>
<td>I was quite relaxed and confident. I was animated and able to use appropriate gestures most of the time.</td>
<td>I was not relaxed and confident. I was reading from the paper.</td>
<td></td>
</tr>
<tr>
<td><strong>Eye contact</strong></td>
<td>I looked up frequently and made eye contact with everyone.</td>
<td>I looked up sometimes and made eye contact with everyone.</td>
<td>I did not look up and made no eye contact.</td>
<td></td>
</tr>
<tr>
<td><strong>Content</strong></td>
<td>My input was relevant and promoted deeper analysis.</td>
<td>My input was relevant.</td>
<td>My input was irrelevant.</td>
<td></td>
</tr>
<tr>
<td><strong>Listening</strong></td>
<td>I listened attentively without interrupting and was able to incorporate and expand on the contributions of other students.</td>
<td>I was mostly attentive in listening and could appropriately respond to the contributions of others.</td>
<td>I did not listen carefully and could not appropriately respond to the contributions of others.</td>
<td></td>
</tr>
<tr>
<td><strong>Persuasiveness, Structure (PEEL/PEEE)</strong></td>
<td>My speech was very persuasive. Structure was correct.</td>
<td>My speech was relevant and somewhat persuasive. Structure was correct.</td>
<td>My speech was not persuasive. Structure may or may not be correct.</td>
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**WHAT I CAN DO TO IMPROVE MY SPEAKING SKILL:**
**Interactive Game-Based Learning (IGBL) in the Tamil Language Classroom**

**ABSTRACT**

This paper aims to share ideas on how teachers can incorporate fun and feasible teaching approaches into the teaching and learning of Tamil. In particular, the focus is on the use of Interactive Game-Based Learning (IGBL) activities to motivate and engage students. According to Stuart Brown, “play stimulates nerve growth in the portions of the brain that process emotions and executive function” (Brown, 2009, p. 20) Thus, the designed activities will not only connect students cognitively and emotionally to the subject content, but will also fuel their desire to excel and enable them to experience the joy of learning. Moreover, Assessment for Learning (AfL) is also embedded in these activities to monitor students’ learning.

This paper will share ideas gathered from classroom experiences and the impact the strategies employed have had on students’ learning. In addition, suggestions will be given on how to adapt these ideas to cater to students’ diverse learning styles, such that the strategies are applicable to all levels, from primary to junior college.
This paper aims to share ideas gathered from the use of Interactive Game Based Learning (IGBL) activities on how to adapt these ideas to cater to students' diverse learning styles, such that the strategies employed have had on students' learning.


The paper is based on ideas gathered from the use of IGBL activities. The strategies that have influenced students' cognitive and emotional understanding have had an influence on students' learning. The aims of this paper are to motivate and engage students and to share ideas gathered from the use of IGBL activities on how to adapt these ideas to cater to students' diverse learning styles, such that the strategies employed have had on students' learning.


classroom, 2016. ©2016 Rosina Bakam
கிளட்டும் அது நாயக்கருக்கு. அது
நிரந்தரத்துக்குச் சிறு்கலும்
பாடகாளின் பார்க்கலம்.

படம் 1

படம் 2

து நிரந்தரம்

து நிரந்தரம்

படம் 3

பிரிவு நிரந்தரம்

து கிளட்டும்

து கிளட்டும்
தபு விரையாட்டு
இந்த விளையாட்டு கிட்டத்தட்ட தபு விரையாட்டின் மபான்றதான். ஆனால், இவ்விளையாட்டில் தளடத்துத்தளடும் தாற்கள் இடம் தபறா.

பிரமிட்விரையாட்டு
இந்த பிரமிட் விளையாட்டு கிட்டத்தட்ட தபு விரையாட்டில் மபான்றதுதான். ஆனால், இவ்விளையாட்டில் தளடத்துத்தளடும் தாற்கள் இடம் தபறா.
Rosina Bakam has been teaching Tamil Language for the past 19 years. Her current interests are the use of information technology in teaching and learning and also the design of formative assessments across subjects as well as in the Tamil Language Curriculum. She has shared on the use of Information Technology, Game-Based Learning and Extensive Reading at the school, cluster, and national levels. She has also embarked on Action Research and presented papers at International Conferences.

REFERENCES

According to the Primary School Leaving Examination (PSLE) 2016 Chinese Language Analysis Report (SEAB, 2016), upper primary pupils are often unable to accurately identify the main idea when they read Chinese passages, and also lack the ability to infer, analyse, generalise, and evaluate when reading materials in Chinese. This shows that pupils lack higher-level comprehension skills. Thus, it is critical to help pupils acquire higher-level reading comprehension abilities to help them get the key message when they read any article.

SOLO (Structure of the Observed Learning Outcome) Taxonomy (see Appendix 1) has been widely researched and has also proven effective in the teaching of various subjects in recent years, but not in the teaching of Chinese Language (CL) reading comprehension at the primary level. If SOLO is proven effective, we will have the evidence to promote this taxonomy and its strategies to all CL teachers in Singapore, which in turn will help more students improve their level of understanding and, thus, perform better on tests and examinations.

Therefore, this project seeks to explore the impact of SOLO Taxonomy on improving pupils’ higher-level reading comprehension abilities in Chinese Language.

There are many deficiencies in the simplistic and incorrect hierarchy of six steps in Bloom’s Taxonomy, which are best resolved using the SOLO model (Hattie & Brown, 2014).

SOLO Taxonomy provides a simple, reliable and robust model for three levels of understanding – surface, deep and conceptual (Biggs & Collis, 1982). It makes learning visible in any situation where there is a focus on learning. This model describes the five distinct levels of learning outcomes that show the learner has: no idea (pre-structural), one idea (uni-structural), several ideas (multi-structural), related ideas (relational), and extended ideas (extended abstract).
RESEARCH PURPOSE, QUESTION AND HYPOTHESIS

Research Purpose

Upper primary pupils should be able to understand reading materials, make inferences through vocabulary and sentence structure, discover hidden meaning through close reading, and to summarise the content, including characters, main idea, and key messages (CPDD, 2015).

Yet, it was found that Primary 6 (P6) pupils are unable to fully understand a passage and, hence, are unable to consolidate the different clues to give the correct answer (SEAB, 2016). They often struggle with ways to identify the most important elements in the text, identify clues and evidence to make inferences, and combine information into new thoughts. Primary 5 (P5) pupils need to be equipped with higher-level reading comprehension abilities, including the ability to relate to and extend information, before they sit for their national examination in P6.

From the research available, we believe SOLO Taxonomy can improve P5 pupils’ comprehension abilities.

Research Question

Our research question was: Does SOLO Taxonomy improve Primary 5 pupils’ abilities to infer, analyse, generalise, and evaluate in Chinese Language reading comprehension?

Research Hypothesis

Pupils who use the SOLO model in CL comprehension will improve their abilities to infer, analyse, generalise, and evaluate. This will enable them to identify the main ideas of the passages they read.
Participants
Our participants comprised 60 students taking CL from 3 schools. They are all 11-year-old P5 pupils of mixed ability, with both high-performance (HP) and low-performance (LP) pupils, and comprising both genders.

Duration of Implementation
There were 3 sessions of intervention spread over a period of 4 weeks, with each session lasting 1.5 hours.

Intervention Procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
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<tbody>
<tr>
<td>Step 1:</td>
<td>Administer a pre-test to determine the comprehension skills in which pupils are weak, and whether they are able to find the main ideas in texts. The pre-test was marked by two teachers to ensure marks were awarded fairly. A difference of more than 0.5 marks would necessitate a third marking. If no third marking was required, the average mark was recorded.</td>
</tr>
<tr>
<td>Step 2:</td>
<td>Administer a pre-perception survey (see Appendix 2) to find out whether pupils find reading comprehension difficult, and assess their confidence levels in answering different higher-order thinking questions.</td>
</tr>
</tbody>
</table>
| Step 3: | Conduct intervention lessons:  
1. Use 3 passages selected from the P5 CL textbook  
2. Employ strategies in class (see Appendix 1), including:  
   I. SOLO symbols to make thinking and learning visible;  
   II. SOLO visual process maps to bring in ideas and patterns for description, explanation, and generalisation, so as to prompt thinking behind answering;  
   III. Scaffolding with effective prompts such as “because …”, “so that”, “what if …”, “I think…”;  
   IV. Using academic verbs such as ‘list’, ‘explain cause and effect’, and ‘predict’, that align to the task and learning outcomes;  
   V. ‘Think–pair–share’ group work in constructing knowledge and ideas; and  
   VI. Rubrics to self-check and monitor outcomes. |
| Step 4: | Administer a post-test to determine whether pupils have improved in their higher-level comprehension skills, including the ability to infer, analyse, generalise, and evaluate. The post-test was marked by two teachers to ensure marks were awarded fairly. A difference of more than 0.5 marks would necessitate a third marking. If no third marking was required, the average mark was recorded. |
| Step 5: | Administer a post-perception survey (see Appendix 2) to measure pupils’ confidence levels in answering higher-level comprehension questions (SOLO levels: relational and extended abstract). |
| Step 6: | Conduct interviews with pupils to find out whether they find SOLO useful, and how SOLO has helped them in understanding the passages. |
| Step 7: | Collect pupils’ work (see Appendix 3) as evidence of their improvement in reading comprehension levels. |

ANALYSIS AND RESULTS

Research Purpose
An analysis of the pre- and post-test results revealed the following findings.

Table 1: Comparison of T scores of Pre- and Post-test

<table>
<thead>
<tr>
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<th>Pre-test</th>
<th>Post-test</th>
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<tbody>
<tr>
<td>Mean</td>
<td>3.83</td>
<td>4.95</td>
</tr>
<tr>
<td>SD</td>
<td>2.52</td>
<td>2.23</td>
</tr>
<tr>
<td>T-test (p value)</td>
<td>0.00035</td>
<td></td>
</tr>
</tbody>
</table>
Comparing the two scores (see Table 1):
- Overall, there is a 1.12 mark improvement in the mean score.
- For both pre- and post-tests, the SD remained consistent.
- The results are statistically significant ($p$-value < 0.05).

Table 2: Comparison of Mean Scores for Individual Questions

<table>
<thead>
<tr>
<th>Qn</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qn 1</td>
<td>0.616</td>
<td>0.980</td>
<td>+0.363</td>
</tr>
<tr>
<td></td>
<td>0.580</td>
<td>0.597</td>
<td>+0.017</td>
</tr>
<tr>
<td></td>
<td>0.000012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qn 2</td>
<td>0.824</td>
<td>1.545</td>
<td>+0.721</td>
</tr>
<tr>
<td></td>
<td>0.562</td>
<td>1.131</td>
<td>+0.569</td>
</tr>
<tr>
<td></td>
<td>0.000049</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qn 3</td>
<td>0.646</td>
<td>1.082</td>
<td>+0.436</td>
</tr>
<tr>
<td></td>
<td>0.586</td>
<td>0.705</td>
<td>+0.119</td>
</tr>
<tr>
<td></td>
<td>0.00012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qn 4</td>
<td>1.311</td>
<td>0.672</td>
<td>-0.639</td>
</tr>
<tr>
<td></td>
<td>1.302</td>
<td>0.577</td>
<td>-0.725</td>
</tr>
<tr>
<td></td>
<td>0.00023</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qn 5</td>
<td>0.496</td>
<td>0.696</td>
<td>+0.201</td>
</tr>
<tr>
<td></td>
<td>0.622</td>
<td>0.499</td>
<td>-0.123</td>
</tr>
<tr>
<td></td>
<td>0.028</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comparing each question:
- Pupils generally improved for Questions 1, 2, 3, and 5, with the improvement ranging from 0.2 to 0.7 marks (see Tables 2 and 3, and Figure 1).
- $T$-test $p$-value < 0.05 shows that the results are statistically significant from Qn 1 to Qn 5.
- There is a decrease in the mean and standard deviation (SD) for Qn 4 after the intervention (see Tables 2, 3, and 4, and Figures 1 and 2). Qn 4 requires pupils to analyse and generalise the main idea of the whole passage, which is more difficult. Pupils have not improved in that ability.
- The difference in SD for Qn 2 (see Table 4 and Figure 2) shows that the improvement is not broad-based; not all pupils benefited equally from the intervention.
- The improvement in marks for each individual type of question is not tremendous as it is difficult to see significant improvement within a short span of time. The pupils will need more practice to learn how to link and relate ideas.
Table 5: Pre- and Post-perception Survey Results

<table>
<thead>
<tr>
<th>Question</th>
<th>Pre</th>
<th>Post</th>
<th>Somewhat Understand</th>
<th>Understand</th>
<th>Totally Understand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current level of understanding of teacher teaching reading comprehension</td>
<td>0%</td>
<td>9%</td>
<td>19%</td>
<td>35%</td>
<td>46%</td>
</tr>
<tr>
<td>Difficulty understanding reading comprehension questions</td>
<td>63%</td>
<td>68%</td>
<td>33%</td>
<td>13%</td>
<td>5%</td>
</tr>
</tbody>
</table>

An analysis of the pre- and post-perception survey results (see Table 5) revealed the following findings:

- **After the intervention, 10% of pupils saw themselves as being able to understand reading comprehension.**
- **After the intervention, 20% more pupils thought that the reading comprehension questions are slightly difficult to understand.**
- **After the intervention, there was a decrease in ‘confident’ and ‘very confident’ levels for all questions.**
- **Although the intervention period was only four weeks, there was an overall increase of 1.12 marks in pupils’ overall results. There is a possibility that when the intervention period is lengthened, the effect on pupils’ performance would be greater.**
- **Time constraints made our interventions rather challenging. We needed to complete 3 chapters in 4 to 5 weeks, which included giving out pre- and post-tests. We could proceed with the intervention only after we had covered the examination topics.**
- **Due to inflexibility in arrangement, one of our sample classes required a colleague, not part of our research team, to conduct the intervention. We observed there were slight differences in the way she used the lesson plans and conducted the lesson activities.**

**LIMITATIONS**

- **We did not have the luxury of control and experimental groups in each school. If we had had control groups, it would have improved the accuracy of the results.**
- **There were two extremes in the abilities of the pupils in our samples – high-performance and low-performance. We do not know which group actually benefited more, or less, from our intervention.**
- **The weaker pupils will need a lot of scaffolding questions to guide them to complete the maps.**
- **It is the first time SOLO Taxonomy has been interpreted and adapted for teaching CL comprehension skills. We did not have any past research to which we could refer.**

**CONCLUSION**

In summary, the p values were statistically significant, demonstrating that students did benefit from SOLO Taxonomy and scored higher in the assessment of CL comprehension. Thus, although the results were not tremendous due to the short time span of the intervention, the findings confirmed the hypothesis that pupils who used...
the SOLO Taxonomy model in CL comprehension would improve in their ability to infer, analyse, generalise, and evaluate. This enabled them to identify the main ideas of the texts they read.

This aligns with our literature review, which found SOLO Taxonomy to be powerful in distinguishing the differences in levels of questions and effective in close reading of texts. Through our research, there is sufficient evidence to believe that CL teachers in Singapore can adopt SOLO Taxonomy.

Our survey also found that 10% of the pupils saw improvement, which was a good start to the implementation of SOLO Taxonomy. However, the students’ perception of increased difficulty and decreased confidence levels means that more time is needed to cultivate students’ abilities with SOLO Taxonomy. Four weeks of intervention is only sufficient to introduce the concept to students, and is not enough for them to be familiar with this framework and to understand it.

Beyond the research, it was heartening to see pupils participating actively in class during the intervention. Many students were enthusiastic and desired to elevate their level of understanding. Teachers are looking forward to assessing the level each student has reached, adjusting their teaching strategies accordingly, and making decisions on the next steps for learning. In addition, since the SOLO Taxonomy framework is useful in improving CL comprehension skills, the potential is great for it to be used in other areas, such as in improving composition writing or oral skills.

REFERENCES


Singapore Examinations and Assessment Board (SEAB). Primary School Leaving Examination (PSLE): 2016 Subject Reports.


ABOUT THE CONTRIBUTORS

Yang Xue Hui, Teng Kang Lee, Lilian Wong, Chow Yee San, and Teo Geok Hock are Chinese language Senior Teachers from both primary and secondary schools, with more than 10 years of teaching experience each. After SOLO pedagogy was introduced to them during their Teacher Leaders Programme 1 (TLP1) course, they decided to pick it up for research as they found it interesting, flexible and applicable to all aspects of teaching and learning. They have conducted many sharing sessions to promote the use of SOLO Taxonomy in teaching comprehension skills, in order that more teachers may be equipped to help their students improve their higher-level reading comprehension skills in the Chinese language.
### Appendix 1

#### SOLO Taxonomy

<table>
<thead>
<tr>
<th>No idea</th>
<th>One idea</th>
<th>Many loose ideas</th>
<th>Related ideas</th>
<th>Extended ideas</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prestructural</strong></td>
<td><strong>Unistructural</strong></td>
<td><strong>Multistructural</strong></td>
<td><strong>Relational</strong></td>
<td><strong>Extended abstract</strong></td>
</tr>
<tr>
<td>No idea</td>
<td>One idea</td>
<td>Many loose ideas</td>
<td>Related ideas</td>
<td>Extended ideas</td>
</tr>
<tr>
<td>Learning outcomes show unconnected information, no organisation.</td>
<td>Learning outcomes show simple connections but importance not noted.</td>
<td>Learning outcomes show connections are made, but significance to overall meaning is missing.</td>
<td>Learning outcomes show full connections made, and synthesis of parts to the overall meaning.</td>
<td>Learning outcomes go beyond subject and makes links to other concepts – generalises, predicts, evaluates.</td>
</tr>
<tr>
<td>define, name, label, identify</td>
<td>describe, list, elaborate</td>
<td>sequence, classify, compare and contrast, explain causes, explain effects, analyse</td>
<td>generalise, predict, evaluate, create</td>
<td></td>
</tr>
</tbody>
</table>
### Appendix 2: Pre- and Post- Perception Survey

学生姓名：___________________  日期：______________

请在适当的表格内打勾(√)：

1. 老师平时讲解阅读理解时，你明白多少?

<table>
<thead>
<tr>
<th>不明白</th>
<th>有点儿明白</th>
<th>还好</th>
<th>明白</th>
<th>完全明白</th>
</tr>
</thead>
</table>

2. 你觉得平时在回答阅读理解的问题时有多难?

<table>
<thead>
<tr>
<th>很难</th>
<th>一点难</th>
<th>还好</th>
<th>容易</th>
<th>很容易</th>
</tr>
</thead>
</table>

3. 做前测的问题时，你对回答第一道题有多大信心?

<table>
<thead>
<tr>
<th>没有信心</th>
<th>有点儿信心</th>
<th>还好</th>
<th>有信心</th>
<th>很有信心</th>
</tr>
</thead>
</table>

4. 做前测的问题时，你对回答第二道题有多大信心?

<table>
<thead>
<tr>
<th>没有信心</th>
<th>有点儿信心</th>
<th>还好</th>
<th>有信心</th>
<th>很有信心</th>
</tr>
</thead>
</table>

5. 做前测的问题时，你对回答第三道题有多大信心?

<table>
<thead>
<tr>
<th>没有信心</th>
<th>有点儿信心</th>
<th>还好</th>
<th>有信心</th>
<th>很有信心</th>
</tr>
</thead>
</table>

6. 做前测的问题时，你对回答第四道题有多大信心?

<table>
<thead>
<tr>
<th>没有信心</th>
<th>有点儿信心</th>
<th>还好</th>
<th>有信心</th>
<th>很有信心</th>
</tr>
</thead>
</table>

7. 做前测的问题时，你对回答第五道题有多大信心?

<table>
<thead>
<tr>
<th>没有信心</th>
<th>有点儿信心</th>
<th>还好</th>
<th>有信心</th>
<th>很有信心</th>
</tr>
</thead>
</table>
课堂实施举例：以《小鸟的呼唤》为例

总的来说，我了解了我们应该要保护环境。因为如果我们没有保护环境，那我们就没有办法居住在一个既美丽又清洁的环境。
总的来说，这让我很伤心难过。因为如果海又黑又臭，我们的鱼会中毒，鱼会越来越少，人们就会很少鱼吃。
课堂实施举例：以《小鸟的呼唤》为例

概述

人们保护环境：
- 不可以污染水和空气
- 不能乱砍树
- 不能在海边乱丢垃圾

解释

- 人们就没有干净的水可以喝，和新鲜的空气可以呼吸。
- 没有了树林，我们没有纸可以用，少了阴凉的地方，也没有新鲜的空气。
- 海洋的生物会死掉。

举例

- 烟雾的时候，我们呼吸困难。
- 地球的变热。
- 很多海洋生物因为水太脏或吃了垃圾死掉。

评价

小鸟呼唤人们保护环境的作法的确有用。

总的来说，从这个图表中让我了解到

因为人们就会有环保意识，地球暖化的情况才有可能改善，我们才会有个舒服的居住环境。
以前我不知道很多东西，可是现在我知道怎么解决问题
“小课堂”如何能有“大收获”？
——中国通识课例教学研究探析

张卫东
安凤云
王燕春
德明政府中学

摘要

中国通识对本地学生来说，是一门非常有挑战性的课程。德明政府中学中国通识教学团队的老师们，从课堂这一教与学集会点入手，以“读、议、讲、评、练”的教学模式贯穿其中，分四个阶段对课例教学进行了积极探索和认真研究。在此过程中，师生双方都获益良多。

1. 研究缘起

中国通识是教育部为打造精通中西双语双文化人才，面向高中学生开设的课程。内容主要涉及中国1978年改革开放以后在政治、经济、社会、外交等领域的发展与变化，旨在促进学生对当代中国的了解，培养他们批判性思维和跨范畴思考的能力。

随着中国的影响日益扩大，这门课程的前瞻性和重要性愈显突出。然而，在多年的教学实践中，我们也发现有一些困难和问题经常困扰着老师，主要表现在以下几个方面：

一是庞杂的课程内容与有限的课时之间存在矛盾。中国通识的内容覆盖面非常广，而且大都复杂而多变。这些内容要在每周只有4个小时、教学时间不到两年的课堂上消化吸收，难度非常大。

二是较高的培养目标与较弱的学生基础之间存在矛盾。通过课程的学习，学生应该能以华文为媒介，对当代中国内政外交的各个方面作出有理有据、全面、平衡而且跨范畴的独立分析。这对于对中国的了解普遍不足的本地学生来说，任务十分艰巨。

三是理想的学习效果与传统的教学方式之间存在矛盾。在中国通识课堂上，我们尝试根据教学专题的不同特点，分别采用不同的教学方式和课堂活动，鼓励学生积极参与和主动学习，并从多方面提升学生的学习能力。但总体上还是放手不够，学生自学、讨论和呈现的机会偏少。同时，各种教学活动的安排也相对独立，欠缺系统化的合理设计。结果往往是欲速而不达，事倍功半。

经过反复讨论，我们认为，要解决上述矛盾，须以课堂教学这个中心和关键环节为着力点。课时有限，就需要提高课堂效率；学习基础相对较弱，就需要师生合力和同侪互助；教学效率偏低，就需要转变观念，真正转向“以学生为中心”。

因此，我们决定本次研究的核心任务为，从课堂入手，通过课例教学研究努力扩展和深化学生学习的实际收获。

2. 研究实践

2.1理论准备

我们深知，理想的课堂教学一定不是孤立的，必然要和其他教学环节紧密相连并相辅相成。本着这样的思路，按照中国通识的培养目标，我们在教学模式的构建和反思上借鉴了很多实证研究的优秀成果。尤其是：
A. 上海静安区教育学院附属学校张人利校长的“后茶馆式”教学（读、议、练、讲）的模式。

B. 台北市立中山女子高级中学张辉诚老师的翻转教学法——“学思达”模式。

这些教学法注重学生们的自学、思考、讨论与表达呈现等，与我们的教学目标和期望十分契合，给了我们很大启发和信心。

经过研究、讨论，配合中国通识的教学要求，以及学生的学习需要，我们将多种教学方法相结合，探索出了一个新的教学模式——“读、议、讲、评、练。”

“读、议、讲、评、练”的教学模式，强调与重视学生的自我阅读、主动思考、互助讨论及呈现技巧、信心胆量等多方面的能力，并且让学生们在刚拿到任务的时候，就已经知道接下来的各项目要求、学习进程，易于主动计划与管理整个学习过程。这种模式增加了学生们自修和讨论的时间，让学生们更主动地参与到学习过程中来，在学习和评估的过程中，更清楚地了解与掌握教学目标与评鉴标准。

通过这种教学模式，我们尝试在课堂教学中，将阅读思考、分组讨论、自评互评、口头报告、练习巩固等各种有效的教学方法和教学环节灵活地整合在一起，让学生们的自主学习更有计划性、系统性，也力求使学生得到合作、表达等多方面的锻炼。

2.2认真规划

我们把研究分为四个阶段：

一、老师们共同讨论设定研究目标，完成教学设计，并集体备课。

二、确定一名老师上课，其余老师观课，并在课后进行对话评课，再反思改进。

三、在反思改进的基础上进行第二轮上课观课，并在课后进行第二轮的对话评课和反思改进。

四、总结经验，分享交流，并策划新一轮的持续跟进研究。

课堂活动以“读、议、讲、评、练”的方式贯穿于整个教学过程中。

为提高研究的质量和效果，我们邀请了华文教研中心的张曦珊特教参与规划、观课与讨论，也邀请了教育部戴紫仪老师、郑璟薇老师参与观课。

2.3课堂实践

第一阶段——设定目标、教学设计、集体备课

在筹备研究活动时，鉴于高二学生已进入会考的备考阶段，我们决定把研究活动放在高一的两个班级进行。按照教学进度，本次研究只能在经济与政治课题之间选择。由于当时教学进度中的政治课题比较复杂，而经济课题中的“能源问题”相对独立，更适合开展此研究。因此，我们把这次的教学内容锁定在“能源问题”上。“能源问题”总共需要3个半小时的课时，分两次完成课堂教学。用于课例研究教学的是后1.5小时。

在研究活动中，学生主要应学习并探讨以下内容：

——中国能源需求问题带来的影响

——解决中国能源需求问题的对策

同时，学生还应该思考以下延伸问题：

——如何评价中国能源需求问题带来的影响?

——中国政府解决能源需求问题的努力在多大程度上是有效的?
——你对中国解决能源需求问题有何建议？这些建议如何实施？

在此阶段，我们通过集体备课的方式，对教案进行了修正和完善，也确定了先后两次观课的时间。

与此同时，按照上述教学目标，以“读议讲评练”的教学模式为脉络，我们设计出了具体的活动安排：

读。学生阅读资料和观看视频。为此，我们在课前向学生印发了老师们准备的参考讲义、文本资料和视频，也鼓励学生根据需要自行搜集相关资料。

议。每班分3组，学生以小组为单位，讨论两项内容，并准备在课堂上呈现：一是中国能源需求问题带来的影响。要求层次清楚，论据有力，有正有反，并且跨范畴。二是解决中国能源需求问题的对策。要求先介绍中国政府为解决能源需求问题所做的努力，并进行评价，再提出自己的建议。

讲。课堂上随机抽取两组进行呈现。抽中的小组只呈现其中一个问题。每组呈现时间为10-15分钟。每位小组成员均需呈现部分内容，分工由各组自行分配。呈现后要有问答环节。

评。一是学生评。呈现后，没有呈现的其余两组要对呈现作出简要评价，并提出改进建议。每组提出2-3个问题供呈现小组回答，最后填写小组呈现评分表。在此环节中，老师会视情况提示另两组进行补充，也会视情况提问或追问。二是老师评。老师会点评学生的呈现和学生间的互动。主要就内容、思路作出评价和补充。老师也会在学生呈现和讨论后，提醒学生填写参考讲义上的空白页，将学习成果记录下来。

练。课后学生需要完成一道问答题，即“中国有能力解决能源短缺问题。试加以讨论”，以课后练习来检验和巩固学习成果。

第二阶段——上课观课、对话评课、反思改进（第一轮）

2017年5月16日，第一轮课堂实践如期进行。课堂上，观课老师主要观察学生的情绪状态、交流互动状态、思维状态、身体语言（小动作、表情神态）、学习效果等。这既包括呈现者的表现，也包括听众的表现。

在反思评价时，授课老师首先表达了自己感受，观课老师相继提出看法和意见。老师们一致认为，从学生的整体表现和接受能力来看，此课达到了教学目标，但一些教学细节还需进一步改进。比如，呈现限时不严，略显拖沓，不利于学生把握关键内容；没被抽到的组感到遗憾；学生用互评表进行同侪互评时没有给出统一时间，造成有的组忙于打分而影响课堂讨论；呈现小组缺少自评，自我反思有待加强；同学间的评价有形式化迹象；有位学生没有参与讨论；学生所用的呈现课件有的部分详略不当，重点内容不够突出。

针对反思结果，老师们对教学设计从学生呈现和听讲两方面进行了修改。在呈现方面，呈现任务由两个分解为三个，即中国能源需求问题带来的影响及其实现，中国政府为解决能源需求问题的努力及其评价，对中国解决能源需求问题的建议。每组的呈现时间也做出了相应调整，并严格限制呈现时间，使每个小组都有机会上台呈现。增加了呈现小组自评。对呈现的格式与方式的要求也作出了更新，突出了呈现目的和效果。

在听讲方面，要求更加具体、明确和严格，比如，同学呈现时，听众应做好必要的记录，不能同时准备自己的任务。学生互评环节安排了统一的打分时间。呈现结束后，学生对呈现进行简要评价时，要求有明确证据。

第三阶段——上课观课、对话评课、反思改进（第二轮）

2017年5月20日，第二轮课堂实践在另外一个班进行。课堂上，授课老师针对改进
建议对教学过程加以调整，并针对学生的表现，随时加以提醒。观课老师在观察学生的课堂表现时，重点观察教学策略调整处学生的表现在，随时加以提醒。观课老师在观察学生的课堂表现时，重点观察教学策略调整处学生的表现。

课后，老师们又进行了认真讨论。大家认为，第二轮课堂实践有了明显改进。比如，时间掌控较严，各组均有呈现，学习参与与反馈更强；学生评价时，有理也有据，学习质量更加凸显；老师追问更能激发更多学生的深层思考；学生互评有统一的打分时间，在进行其他环节时不再有同学为此分心。

同时，老师们也提出了可以改进的地方。比如，各环节之间的节奏还可以更紧凑；导入新课前，由于学生复习不够，内容不熟，老师提问提问时，进展较慢；有一组学生在评价之后，没能提出问题，显示准备不足和思考不够；呈现课件有进步，但还需要再突出关键字、关键句，因为这也是检验思维的一种方式；针对学生们的分组讨论和呈现时的表现与学生反馈，可以调整分组。

第四阶段——总结经验、分享交流、持续研究

两轮的课堂实践后，我们向全体学生发放了调查问卷。问卷结果显示，绝大多数同学对这种教学模式的作用持肯定意见。但在一些题目中，也分别有一、两位同学选择了“不同意”。我们通过进一步访谈发现，持“不同意”意见的同学主要是对自己的表现不够满意，觉得自己做得还不够，进步不明显，由于习惯不好或基础较差，这种模式也很难一下子帮助自己进步。尽管如此，同学们都表示这种模式能够促进自己主动学习，主动思考，有助于发现差距，了解多元观点。相信随着基础的夯实和能力的提升，这种模式带来的益处会更明显。

表一：学生反馈表

<table>
<thead>
<tr>
<th>读议讲评练的教学模式可以让我：</th>
<th>非常同意</th>
<th>同意</th>
<th>不同意</th>
<th>非常不同意</th>
</tr>
</thead>
<tbody>
<tr>
<td>在课前更认真阅读学习资料</td>
<td>37.5</td>
<td>58.3</td>
<td>4.2</td>
<td>0</td>
</tr>
<tr>
<td>更主动发现和提出问题</td>
<td>37.5</td>
<td>50.0</td>
<td>12.5</td>
<td>0</td>
</tr>
<tr>
<td>更习惯与同学们互相讨论切磋</td>
<td>37.5</td>
<td>58.3</td>
<td>4.2</td>
<td>0</td>
</tr>
<tr>
<td>更了解同学们的想法、考虑问题更全面</td>
<td>29.2</td>
<td>62.5</td>
<td>8.3</td>
<td>0</td>
</tr>
<tr>
<td>训练胆量，当众呈现时更自信、自然</td>
<td>29.2</td>
<td>62.5</td>
<td>8.3</td>
<td>0</td>
</tr>
<tr>
<td>更了解和重视电子简报呈现形式与技巧</td>
<td>25.0</td>
<td>58.3</td>
<td>16.7</td>
<td>0</td>
</tr>
</tbody>
</table>

评分表、评分标准和评鉴活动，让我更了解学习目标与要求，帮助我有意识地做到：

| 跨范畴思考 | 54.2 | 45.8 | 0 | 0 |
| 批判思维 | 37.5 | 58.3 | 4.2 | 0 |
| 观点明确 | 45.8 | 50.0 | 4.2 | 0 |
| 举例论证 | 50.0 | 45.8 | 4.2 | 0 |
| 呈现后的“自我评价”，让我更好地反思自己的思维，发现自己的优点和缺点 | 33.3 | 54.2 | 12.5 | 0 |
| 课后作业练习让我更加全面地复习思考，巩固所学，发现新问题 | 41.7 | 58.3 | 0 | 0 |
| 老师针对课后练习的讲评，帮助我更好地掌握课程内容，进一步理清思路 | 54.2 | 45.8 | 0 | 0 |
在进行全面总结的基础上，我们在淡马锡初级学院向东区其他学校的老师们分享了研究情况，也获得了很多支持和宝贵的意见。我们也计划在日后的教学中，继续改进和跟进研究。

3. 研究结论与反思

3.1 研究结论

本次课例教学研究，让我们切身感受到，小课堂也能有大收获。课堂虽小，但有无限延伸的空间，课时虽有限，却可释放出无穷的魅力和影响。而这些，都离不开以课堂为平台，按照“读、议、讲、评、练”的教学模式，落实学习过程中学生的中心地位，培养学生学习的主动精神。

本次研究活动使教与学双方都获益良多。

对于教师而言，有助于教师团队务实合作，共同观察和诊断教学中存在的问题；有助于深入教学研究，对教与学进行持续改进与优化；有助于探究师生同台的模式与效应，以教学创新扩大学生的实际收获。

对于学生而言，有助于实践和锻炼综合学习能力；有助于提升与加强同侪合作能力；有助于运用与提高沟通与整合能力；也有助于建立与增强自信及包容能力。

3.2 反思

通过本次研究，以下几点对我们触动很大：

一是学生的自学潜力往往比老师想象的要大。身处互联网时代，“闻道”不一定再分“先后”，学生也可能通过自学达到“术业有专攻”。传统的“传道授业解惑”式教学已过时了。在本次研究的课堂呈现和讨论环节，不时有闪光的观点和独到的分析出现，相异构想不断迸发。而这些，都得益于学生自主而广泛的自学。

二是把课堂学习的主动权还给学生，可以达到更好的效果。正所谓“告诉我，我会忘记；演示给我看，我会记住；让我参与其中，我就会明白”。在“明白”的基础上产生有价值的主见，正是我们所追求的教学效果。

三是以学生为主效率更高。把课堂还给学生，看似不如老师讲解更有效率，但从实践来看，它能更好地激发学生的求知兴趣，培养他们的学习乐趣，促使他们自主运用更多的课外时间充实自己。在以学生为主的教学模式上，老师的讲解不再是大水漫灌，而是有的放矢，画龙点睛，往往事半功倍。

四是精进教学无止境。教学没有最好，只有更好。教学对象、课程内容等要素的变化，更要求课堂教学也要同步改进。教学可以有不同模式，但都不能教条和僵化，比如，“读、议、讲、评、练”模式必须根据不同需要，灵活增减部分教学环节或改变环节顺序。在改进教学的过程中，教师团队通过多维角度和集体智慧所发挥的合力，是老师凭借个人努力没有办法企及或取代的。
参考文献

张人利（2016）《后“茶馆式”教学的实践指导》上海教育出版社

张辉诚（2015）《学•思•达：张辉诚的翻转实践》台北亲子天下出版社

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Low-progress students seem to have more challenges solving word problems, probably because they are not very familiar with mathematical terms or vocabulary. Providing appropriate language support is important for all students. In a mathematics classroom, this support includes the ongoing development of everyday vocabulary, such as ‘product’, ‘quotient’, ‘sum’, ‘difference’, ‘average’, etc. It is imperative that every student masters the basic mathematical terms before advancing to more challenging terms.

The purpose of this study is to determine whether teaching mathematics key vocabulary words, phrases, and sentences will improve upper primary students’ Mathematics test scores. A class of low-progress students was engaged in this study. This study aims to look into strategies to help the low-progress learners identify the common concepts found in word problems, so as to enable them to be more confident in solving such problems. In this paper, the two strategies used, one of which is an ICT tool, are manageable and can be used for all groups of students at various differentiated levels.

ABSTRACT

INTRODUCTION

Low-progress students seem to have more challenges solving word problems, probably because they are not very familiar with mathematical terms or vocabulary. Providing appropriate language support is important for all students. In a mathematics classroom, this support includes the ongoing development of everyday vocabulary, such as ‘product’, ‘quotient’, ‘sum’, ‘difference’, ‘average’, etc. It is imperative that every student masters the basic mathematical terms before advancing to more challenging terms.

LITERATURE REVIEW

Carlson & Moses (2001) state that children are able to carry out tasks set for them as they learn to focus and direct their attention accordingly. These tasks would include paying attention, recalling instructions, and completing individual assignments or group activities. However, for them to do better on such tasks and complete them more efficiently, students must have the ability to remain focused on the tasks at hand despite distractions in class, such as students speaking out of turn, noisy classroom situations, and classmates doing things that are not relevant to the activities assigned.

Being well-developed in oral proficiency in English and able to manage contextual aspects may be a critical step in improving word-problem-solving skills (Orosco, 2014). Children need to develop skills to extract pertinent information from a word problem before they can proceed to solve it. Rupley & Nichols (2005) have emphasised that English vocabulary knowledge, good listening comprehension skills to pick up important pointers, and the ability to manage contextual aspects of language, which includes providing direct and explicit instructions with mathematical terminology and concepts, are linked to improving comprehension. This is especially so when developing word-problem-solving skills.

Having an extensive vocabulary knowledge may provide students with the advantage of understanding the varied contexts of word problems. Hence, this may in turn help these learners make sense of the mathematical content (Gay, 2008). Their being familiar with the mathematical terms, phrases, or contexts is the key component to comprehending the gist of the word problems. If this skill is developed well and the activities are designed according to students’ various progress levels, gains in
In a mathematics class, students need to be able to explain their problem-solving strategies verbally and in written form. They need to be able to use mathematical language to express their ideas and strategies when communicating with one another. As they share their thoughts or mathematical processes with one another, they must be able to listen to one another and provide feedback to rectify misconceptions or clarify uncertainties. This is especially so for low-progress learners who tend to prefer to remain quiet as they are afraid of making mistakes or lack confidence.

Anthony (2009) and Hunter (2005) state that when students are able to apply mathematical vocabulary in their ‘mathematical talk’, they will be able to clarify and organise their thoughts, simplify their personal and collective group ideas and make sense of these thoughts, use available resources and ride on one another’s ideas to challenge and broaden their understanding of the tasks assigned, and become more independent in their discussions, with the teacher acting as a facilitator.

Using the “Talk Moves” strategy (Hunter, 2005) has a strong impact on building the repertoire of mathematical vocabulary. Students are encouraged to participate in mathematical discussions through the following ‘5-Talk Moves’ strategy:

- Revoicing / Rephrasing (e.g. “So you are saying that...”)
- Repeating (e.g. “Can you repeat what she has just said in your own words?”)
- Reasoning (“Do you agree with her solution? Why or why not?”)
- Adding On (“Would someone add on to the solution?”)
- Wait-time (“Take your time...”)

In general, language skills have become increasingly important in the mathematics classroom. The repertoire of a child’s mathematical vocabulary is more likely to influence a child’s success in mathematics. According to Pierce & Fontaine (2009), students are able to analyse the information more efficiently as they are able to comprehend the sums better.

Anthony (2009) and Hunter (2005) state that when students are able to apply mathematical vocabulary in their ‘mathematical talk’, they will be able to clarify and organise their thoughts, simplify their personal and collective group ideas and make sense of these thoughts, use available resources and ride on one another’s ideas to challenge and broaden their understanding of the tasks assigned, and become more independent in their discussions, with the teacher acting as a facilitator.

In our research study, a total of 22 Primary 5 students from two different schools were identified. They were the low-progress learners of the cohort in their respective schools.

- Control Group (CG): 11 girls (all-girls school)
- Experimental Group (EG): 7 boys & 4 girls (co-ed school)

T-tests carried out on the groups’ Primary 4 (P4) Semestral Assessment 2 (SA2), a ‘streaming exam’, showed that there was no significant difference in the two groups’ mean Mathematics scores (see Table 1). Hence, according to Cohen (2007), the students in both EG and CG groups are comparable in terms of mathematics ability.

However, in terms of gender, the two groups were not comparable because there were no boys in the Control Group.

---

**Table 1: T-test Results for CG & EG P4 SA2**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Number of Students</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Standard Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA2 EG</td>
<td>11</td>
<td>35.80</td>
<td>11.00</td>
<td>3.3</td>
</tr>
<tr>
<td>SA2 CG</td>
<td>11</td>
<td>39.55</td>
<td>5.35</td>
<td>1.6</td>
</tr>
</tbody>
</table>

---
A pre-test was conducted for both groups in Term 2. After this, the intervention was carried out in Term 4 over two weeks for about 1 hour per day during Mathematics periods for the EG.

The CG received a typical instructional strategy – direct instruction with the inclusion of some occasional hands-on activities by Teacher A. Teacher A used more of a teacher-centred approach to deliver the lessons, that is, more frontal teaching.

The EG received a math intervention instructional strategy by Teacher B. The intervention activities included the use of an ICT tool, Wordwall, and a card activity, ‘Card Sort’.

**Teaching Methods used by Teacher B**

Teacher B conducted the explicit teaching of key words, phrases, and sentences to elicit responses from her students and to enable her to gauge their comprehension level of these phrases or sentences. She focused on a few common phrases and sentences often used to craft a math word problem. Six different word problems identifiable by question type were chosen: Common Item, Before & After, Constant Total, Double If, Set Value, and Listing.

Teacher B sensitised the EG to the above through the explicit teaching of the key words as the students went through examples, illustrations, and explanations using Wordwall, an interactive web-based tool (see Figure 1). Thereafter, Teacher B elicited the students’ understanding by asking them to illustrate or give examples and to translate the key words into math sentences (equations) on the ‘My Wordwall Worksheet’ (see Activity 1).

![Wordwall](image)

**Figure 1: Wordwall**

**Activity 1: My Wordwall Worksheet**

*Draw pictures, draw models, or give examples to show what these phrases or sentences mean.*

<table>
<thead>
<tr>
<th>1. Difference between 30 and 12</th>
<th>2. Difference between 12 and 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Adam had 108 more cards than Ben</td>
<td>4. A shirt costs $21 less than a bag</td>
</tr>
</tbody>
</table>
To reiterate the concepts taught, Teacher B engaged the students in the ‘Word Problem Worksheet’ (see Activity 2).

Activity 2: Word Problem Worksheet

Match each Question Type to the correct Word Problem.

<table>
<thead>
<tr>
<th>Question Type</th>
<th>Word Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double “IF”</td>
<td>1. Ali and Ben have $55 altogether. Ali and Charles have $45 altogether. Ben has 3 times as much money as Charles. How much did Ali have?</td>
</tr>
<tr>
<td>Total Remains Unchanged</td>
<td>2. John and Peter had an equal number of toys. After John gave away 96 of his toys and Peter gave away 28 of his toys, Peter had 3 times as many toys left as John. How many toys did each of them have at first?</td>
</tr>
<tr>
<td>Listing / Supposition / Guess and Check</td>
<td>3. There were 7 times as many marbles in Box A as in Box B. After Joyce transferred 294 marbles from Box A to Box B, both boxes had the same number of marbles. How many marbles were there in Box A at first?</td>
</tr>
<tr>
<td>Common Item</td>
<td>4. Reena and Pauline had a sum of money each. If Reena gave Pauline $28, they would have the same amount of money. If Pauline gave Reena $35, Reena would have 3 times as much as Pauline. How much did Reena have?</td>
</tr>
<tr>
<td>Before and After Model</td>
<td>5. There were 3 times as many children as adults at a concert on Saturday. An adult’s ticket cost $7 and a child’s ticket cost $3. The theatre collected a total of $6000. How many people were there at the concert?</td>
</tr>
<tr>
<td>Set Value</td>
<td>6. On a farm, there are 3 times as many chickens as rabbits. Given that there are 210 legs altogether, how many rabbits are there on the farm?</td>
</tr>
</tbody>
</table>

Once the students were familiar with the concepts taught, Teacher B engaged them in Activity 3, where she provided the students with two sets of cards – the word problem cards and the concept cards. The students had to sort out the word problems according to the concept cards or vice versa. This was reinforcement for Activity 2.
These activities allowed the students to activate their mathematical processes and schema systematically as they became more familiar with mathematical terms and vocabulary. Teacher B reiterated the important steps to consider in solving any word problem based on Polya’s Problem Solving Model (1945):

1. Read the word problem sentence by sentence.
2. Examine and highlight the important pointers provided, activating the schema.
3. Act on the solution, that is, identify an appropriate strategy to solve the problem.
4. Look back at the solution and the question stem to check for misreading of the problem, misinterpretation of the information, or carelessness in computation.

**COLLECTION AND ANALYSIS OF DATA**

The post-test, which was similar in format to the pre-test, was conducted for both groups in Term 4 after two weeks of intervention for the EG. The test consisted of 9 word problems, with a mark range between 1 and 3 marks, and a base mark of 20 marks. Marks obtained from both groups were recorded and compared (see Tables 2 and 3).

Table 2: Pre-test and Post-test Results for EG & CG

<table>
<thead>
<tr>
<th>Student</th>
<th>EXPERIMENTAL GROUP</th>
<th>CONTROL GROUP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P4 SA2 (100)</td>
<td>EG Pre-test (20)</td>
</tr>
<tr>
<td>1</td>
<td>30</td>
<td>5.5</td>
</tr>
<tr>
<td>2</td>
<td>42</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>38</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>46</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>46</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>47</td>
<td>11</td>
</tr>
<tr>
<td>8</td>
<td>31</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>32</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>46</td>
<td>5</td>
</tr>
<tr>
<td>11</td>
<td>22</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EXPERIMENTAL GROUP</th>
<th>CONTROL GROUP</th>
</tr>
</thead>
<tbody>
<tr>
<td>P4 SA2 (100)</td>
<td>EG Pre-test (20)</td>
</tr>
<tr>
<td>Mean</td>
<td>35.8</td>
</tr>
<tr>
<td>Median</td>
<td>37</td>
</tr>
<tr>
<td>Mode</td>
<td>46</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>11.0</td>
</tr>
</tbody>
</table>
The mean scores for both groups had increased. With the intervention, the standard deviation for the scores for the experimental group had decreased, indicating that the range of scores, as compared to the mean score, had narrowed (see Table 3). The students were able to solve the questions better with the skills they were taught. They were able to comprehend important information on the questions and were better at picking it out. On the other hand, without any intervention, the standard deviation for the scores for the control group had increased, indicating that the range of scores, as compared to the mean score, had widened (see Table 2). This proves that, without constant exposure to mathematical vocabulary and terms, students will struggle with word problems, as language has become a barrier to them.

### STRENGTHS OF THE INTERVENTION

Opportunities were provided for these low-progress learners to identify key words and/or phrases through explicit teaching and guidance. They were taught the skills to identify these words and/or phrases to assist them in deciphering and breaking down key information. The intervention proved to be beneficial as the students became more confident to ‘walk the talk’. The ‘Key’ Wordwall activity (Activity 1) leveraged on the use of ICT that managed to engage low-progress students more effectively. The students were engaged gainfully as they learnt to tap on one another’s strengths.

### CHALLENGES ENCOUNTERED

During the ‘Card Sort’ activity, the low-progress students were involved in three separate small-group discussions where they had to come to an agreement on the final match of all the cards. Unfortunately, these discussions were not recorded by the researcher. An invaluable element that could uncover contingent (not yet known) gaps in comprehending a word problem could have surfaced, but was not captured. In addition, gender-biased convenience sampling and a small sample size of a total of 22 students may have influenced the research findings.

### RECOMMENDATIONS FOR FOLLOW-UP

Instructional design can include fun and interactive activities that provide a meaningful context for low-progress students to develop and apply their mathematical skills. For example, in the ‘Fill-in Math Word Problem’ activity, students can help to create simple problems by filling in the blanks in a math story with the provision of key words (nouns, adjectives, and verbs) and numbers. Other possibilities would be to role-play the story in a math word problem or create comic strips to recount (or retell) the story. In short, these activities could better engage low-progress students and help them discern the story (content and context) in a word problem, as they are easily distracted during lessons and rarely speak or communicate in a math setting.

### Table 3: Pre-test & Post-test Results for the EG

<table>
<thead>
<tr>
<th>Sample</th>
<th>Number of Students</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Standard Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>EG Pre-test</td>
<td>11</td>
<td>4.5</td>
<td>3.4</td>
<td>1.0</td>
</tr>
<tr>
<td>EG Post-test</td>
<td>11</td>
<td>9.8</td>
<td>2.5</td>
<td>1.2</td>
</tr>
</tbody>
</table>

During the 'Card Sort' activity, the low-progress students were involved in three separate small-group discussions where they had to come to an agreement on the final match of all the cards. Unfortunately, these discussions were not recorded by the researcher. An invaluable element that could uncover contingent (not yet known) gaps in comprehending a word problem could have surfaced, but was not captured. In addition, gender-biased convenience sampling and a small sample size of a total of 22 students may have influenced the research findings.
This study reaffirms earlier research that students need support to develop a mathematical language for expressing mathematical ideas, which would allow them to understand a word problem crafted in that language in order to successfully solve the word problem. Hence, it is beneficial to apply this strategy with other topics such as Fractions and Ratio, where there is more mathematical vocabulary that students need to be familiar with. Mathematics teachers can work together to design the resources and use them to conduct the lessons. When teachers are willing to invest the time to help these students, they will earn time in return. The greatest gift will be when the students experience the joy of learning in their Mathematics classes, no longer fearing the subject.

**REFERENCES**


**ABOUT THE CONTRIBUTORS**

Nor Shida Hatu is ST / MA (Upper) in CHIJ (Katong) Primary. She has been teaching for about 19 years and is very passionate about the teaching of Mathematics. She has taught high-progress, middle-progress, and low-progress upper primary students. She believes that every child can learn regardless of ability level and can love Math. She loves to create her own resources so that her students will be exposed to different modes of pedagogy and hence develop the joy of learning.

Fauziah Abdullah currently teaches at Ngee Ann Primary School. She has been teaching upper primary Mathematics for many years. This year will be her 26th year in the teaching service. She has gained experience teaching Mathematics to low-progress students, middle-progress students, and students from the Gifted Education Programme.
The growing emphasis on Problems in Real-World Context (PRWC) allows students to see the relevance of mathematics in real life and increases their cognitive ability in applying concepts to solve real-life problems. The process of solving PRWC tasks strengthens our students’ thinking skills and develops them to be more adaptable in the Volatile, Uncertain, Complex, and Ambiguous (VUCA) environment of the 21st century. Based on our literature review, the crafting of mathematics PRWC for assessment in the past has not been comprehensive. Through our project, we hope that more teachers can benefit by becoming better equipped with a structured thinking process through the use of the ICAE (Identifying Context, Crafting and Refining, Analysing, Evaluation) process to design good PRWC tasks. As they become more confident, they will develop a greater awareness of and a deeper appreciation for mathematics in the real world, eventually sharing their joy of learning and solving PRWC tasks with their students.

• MOE’s Mathematics Framework (Figure 2)
Solving PRWC tasks highlights the central focus of the Mathematics Framework – mathematical problem solving. In the process of solving PRWC tasks, students are encouraged to apply mathematical concepts to the problems and develop process skills such as reasoning, communication, and making connections. All these will enable students to have a better grasp of what the problems demand and be concise in their solutions. Eventually, when students see the relevance and usefulness of mathematics in solving problems in real life, they will gain greater appreciation for and interest in mathematics. Hence, they will be more likely to become independent learners.

ABSTRACT

The growing emphasis on Problems in Real-World Context (PRWC) allows students to see the relevance of mathematics in real life and increases their cognitive ability in applying concepts to solve real-life problems. The process of solving PRWC tasks strengthens our students’ thinking skills and develops them to be more adaptable in the Volatile, Uncertain, Complex, and Ambiguous (VUCA) environment of the 21st century. Based on our literature review, the crafting of mathematics PRWC for assessment in the past has not been comprehensive. Through our project, we hope that more teachers can benefit by becoming better equipped with a structured thinking process through the use of the ICAE (Identifying Context, Crafting and Refining, Analysing, Evaluation) process to design good PRWC tasks. As they become more confident, they will develop a greater awareness of and a deeper appreciation for mathematics in the real world, eventually sharing their joy of learning and solving PRWC tasks with their students.

INTRODUCTION

Mathematics should not be learnt in isolation. It is more relevant and interesting to students only when they see how mathematical concepts can be applied to solve real-world problems. Karweit (1998) defines contextual learning as reality-based learning that provides students with opportunities to make meaning of their disciplinary knowledge and solve problems within a real-world context. The revised Ministry of Education (MOE) Mathematics syllabus for secondary schools has also incorporated assessment on Problems in Real-World Context (PRWC), which signals the need for such learning. In this project, we aim to better equip teachers with a structured thinking process through the use of the ICAE (Identifying Context, Crafting and Refining, Analysing, Evaluation) thinking process to design good PRWC tasks.

Besides achieving the purpose of meeting the curriculum requirements and the assessment criteria, exposing students to PRWC is also in alignment with:

• MOE’s Framework for 21st Century Competencies and Student Outcomes (Figure 1)
PRWC tasks represent a good platform for students to apply what they have learnt to solve problems in a wide variety of authentic contexts. In the process of solving such problems, students are developed to be critical and inventive thinkers as there are numerous considerations and multiple viable solutions to these problems.
Since the implementation of the new GCE O-Level Mathematics (4048) syllabus in 2013, teachers have been attending courses on designing PRWC tasks, yet many still express difficulties in setting such questions. Hence, the team decided to look for articles involving PRWC to find out more about the design of PRWC tasks.

In terms of the use of real-world contexts, Gainsburg (2008) conducted a survey of 62 secondary mathematics teachers. She found evidence indicating that everyday experiences provide a strong foundation for learning mathematical ideas. This guides us towards designing PRWC tasks which are relevant to our everyday lives. She also shared that teachers may have examples from their own experiences which can help in designing PRWC tasks with practical applications. Teachers may also be able to identify colleagues who can lead and help others in this area.

In the aspect of designing PRWC tasks, Cheng (2013) emphasised the importance of designing appropriate tasks. Teachers need to anticipate the trajectory of a student’s thinking from the mathematical and learner-centred perspective to ensure that problems both offer practical experiences and are suitable for assessment purposes. He explained that the computational skills involved must be appropriate for and not be beyond the identified students’ grade level. This reminds teachers to be familiar with students’ mathematical backgrounds and knowledge to date. Another key conclusion he shared was that problems should offer students the opportunity to make decisions on top of developing computational skills.

Bokar (2013) mentioned that teachers need to show students how they can use mathematics in the real world and get them to reflect on their thinking in order to improve their mathematical abilities. The design of problems should provide opportunities for students to make well-grounded decisions involving logical or mathematical reasoning. He also mentioned that one way to solve real-world problems is to get students to reflect on their problem-solving strategies, either in written or oral form. This will help to increase students’ awareness of their thinking processes.

Holder (2015) consolidated five ways to craft better problems to help students develop problem-solving skills and improve their mathematical understanding. She suggested giving students problems and getting them to figure out how to solve the problems before teaching the computational skills involved. In this way, students can develop their own understanding of solving a problem instead of receiving this information from the teacher. The recommended way is to adopt an inquiry-based learning or learner-centred approach. Students’ learning becomes more personal when they figure out how to solve the problem on their own. This guides us towards setting PRWC tasks with an appropriate context instead of merely setting basic computational questions. According to Holder (2015), problems set should be based on realistic ideas that feature familiar settings and ideas.
Due to the lack of literature related to the designing of PRWC tasks, the team decided to develop a structured thinking process to guide teachers in this area. The characteristics of good PRWC tasks were distilled into a concise set of processes which teachers can use to craft appropriate PRWC tasks for assessment and learning. Four broad stages: Identifying Context, Crafting and Refining, Analysing, and Evaluation, are prominent in the proposed process, with specific considerations embedded in each stage (as shown in Figure 3). Using the stages formed, we named the process using the acronym ICAE.

**Stage 1: Identify Context**
A real-world context with broad parameters is first identified to provide the necessary mathematical content and concepts to be assessed. The context identified should allow flexibility in terms of setting questions from the mathematical strands of the Mathematics 4048 syllabus content, namely Algebra, Geometry & Measurement, and Statistics & Probability. The context chosen should also take into consideration the contextual knowledge and computational skills of the targeted level or stream of students. Most importantly, it should provide a platform to assess the process skills, such as reasoning, data analysis, thinking skills, and heuristics, from the ‘Processes’ focus in the Singapore Mathematics Framework adopted by Singapore mathematics educators.

**Stage 2: Craft and Refine**
From the identified context, possible questions aligned to the specifications and syllabus objectives can be crafted. As per typical approaches, the questions should be of
progressive difficulty with scaffolding instructions. The problem should also include complex multi-step tasks to provide differentiated learning for and stretch higher-ability students. Refinement of both the given context and questions is necessary in crafting the entire PRWC task. While context should match reality to provide the students with an authentic problem, the real world is complex with multiple factors to consider. Boundaries to the parameters of the context need to be set to ensure the PRWC task is of an appropriate level of difficulty for assessment. Assumptions of students’ metacognition and thinking trajectories are strong influences in the refinement of the context and questions posed. For example, a straightforward interest compounded annually would be more appropriate than a rolling month-over-month interest in the topic of percentages and finances.

Stage 3: Analyse

The third stage of the ICAE approach constitutes a thorough analysis of the PRWC task. Solutions are designed with consideration for alternative methods to ensure that the limitations defined in the previous stage would allow the same answer to be consistently achieved. Other teachers should be consulted for their different perspectives to ensure fairness in the assessment of the students via the PRWC task. Ultimately, although context can be read subjectively by different audiences, teachers have a social responsibility to ensure that the context delivers an educational or healthy message. For example, if the question is on the probability of winning at the casino, this probability should not be high, so as to discourage gambling. In addition, the mathematical content tested should be aligned strictly with the syllabus documents and the specific instructional objectives of each topic.

Stage 4: Evaluation

The final stage is an evaluation of the suitability of the PRWC task. This involves the administration of the PRWC task to students in anticipation of their responses. After administering the task, the PRWC task is to be refined based on students’ responses. This is essential for the growth and learning of individuals new to crafting PRWC tasks or the ICAE approach. In order to stretch the possibilities of the context used, the PRWC task should also be adapted for other streams and levels, with revised concepts appropriate to the particular stream and/or level.

In summary, while the ICAE thinking process has been categorised into four stages, it is not a one-directional cycle process. Stages 1 and 2 can be looped to refine the question threads of the PRWC task. This is to ensure that the various factors of consideration are encapsulated in the context, questions, and solution(s) of the PRWC task.

Example of Applying ICAE to Craft a PRWC Task: Car Purchase

The following illustrates how we apply ICAE to craft a PRWC task, with explanations for the thought process for each stage.

Stage 1: Identify Context

Possible Question: Mr Lim intends to purchase a car for his family of 4. In his search for a new car, he comes across two cars with these specifications which suit his family’s needs. The car agent informs him that a maximum loan of 60% can be obtained.

Likely topics to be tested:
- Mathematics in Everyday Life (OMV/ Financial Transactions)
- Percentage (Depreciation/ Hire Purchase/ Car Loan)
- Rate (Fuel consumption)

Stream of target group:
- Secondary 4 Express or Secondary 5 Normal Academic

Students’ prior knowledge:
- Hire Purchase
- Simple & Compound Interest
- Rate and Proportion

Stage 2: Craft and Refine

The table below shows the research done for 2 selected car models. Some of the information is relevant, while some is not. Students’ lack of knowledge in OMV and depreciation may require some addressing. Additional charges common to both cars include parking ($120/month), servicing ($220/year) and insurance ($800/year).

<table>
<thead>
<tr>
<th></th>
<th>Mazda 3 1.5 L</th>
<th>Honda Civic 1.6 L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>$102,800</td>
<td>$109,999</td>
</tr>
<tr>
<td>OMV</td>
<td>$15,000</td>
<td>$20,590</td>
</tr>
<tr>
<td>Road Tax (per annum)</td>
<td>$682</td>
<td>$742</td>
</tr>
<tr>
<td>Power (bhp)</td>
<td>118</td>
<td>123</td>
</tr>
<tr>
<td>Fuel consumption (km/h)</td>
<td>17.5</td>
<td>14.9</td>
</tr>
<tr>
<td>Fuel Tank Capacity (litres)</td>
<td>51</td>
<td>47</td>
</tr>
<tr>
<td>Interest (per annum)</td>
<td>2.38%</td>
<td>2.18%</td>
</tr>
</tbody>
</table>

In summary, while the ICAE thinking process has been categorised into four stages, it is not a one-directional cycle process. Stages 1 and 2 can be looped to refine the question threads of the PRWC task. This is to ensure that the various factors of consideration are encapsulated in the context, questions, and solution(s) of the PRWC task.
Stage 3: Analyse
At this stage, we analyse the problem and work out the solutions and marks for these questions:

a) Calculate the minimum down payment required to purchase both cars. [2]

b) If Mr Lim wants to take the maximum loan tender for 7 years to minimise the monthly instalment, select the car he should purchase. [5]

c) In terms of maintenance of the car and petrol consumption, choose the car he should buy assuming that he drives an average of 1600 km monthly. [2]

d) Given that each car depreciates by a constant amount every year and retains half of the OMV after 10 years, calculate the yearly depreciation of each car. [2]

e) Eventually, Mr Lim bought the Honda Civic 1.6L but planned to sell it after 6 years in view of family planning. Find the selling price of his car after 6 years. [2]

Stage 4: Evaluation
After the initial round of assessing students via the PRWC task, a possible question to ponder would be how the problem can be improved in terms of the transition between the questions, the mark allocation, or even the organisation of question parts. In addition, we may explore the possibilities of adapting and refining the problem for use in another level or stream.

RESULTS AND FEEDBACK

Teachers’ Feedback on ICAE
In 2017, at the National Symposium held at Anglican High School and a sharing session held at Dunman High School, the East Zone Centre of Excellence, our team shared the ICAE process. On these occasions, teacher participants attempted to use the ICAE process to set PRWC tasks. Their feedback was captured in the 4 Multiple Choice Questions shown in Figure 4 below. The feedback was obtained via an online polling site: www.menti.com.

![Figure 4: Screenshot of Consolidated Feedback via Mentimeter](image)

Some qualitative feedback from the sessions includes:
- “ICAE is a systematic approach to crafting problems in real-world context.”
- “Use of real-world context makes learning mathematics more insightful and meaningful.”
- “Heightens teachers’ awareness of real-world contexts which can be used for designing problems.”
- “Possible to challenge students to craft more questions for reflective learning.”

Students’ Feedback on PRWC
To convince ourselves that exposing students to PRWC is beneficial, the team decided to test its effects. We conducted 2 revision lessons for 2 classes of similar ability, each with about 40 students. The experimental group was exposed to PRWC during the lesson while the other (control) was exposed to only 1 PRWC task and mainly computational questions.
After the test, a survey was conducted for the experimental group, and the results are shown in Table 1 below.

Table 1: Survey Results (Experimental Group)

<table>
<thead>
<tr>
<th>Question</th>
<th>% of ‘Strongly Agree’ / ‘Agree’</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can understand what PRWC means.</td>
<td>100.0</td>
</tr>
<tr>
<td>I am more confident in solving PRWC tasks.</td>
<td>97.5</td>
</tr>
<tr>
<td>I am able to appreciate the application of mathematics to daily life.</td>
<td>95.0</td>
</tr>
</tbody>
</table>

Some of the qualitative feedback from students when asked what they have learnt and what they wished to explore further is shown below:
- “I can better appreciate how PRWC can apply to different job prospects.”
- “I am interested to find out how complex building structures can be embedded in PRWC.”
- “We can get into groups and design PRWC for classmates to solve.”
- “How PRWC can help us in our lives in future.”

Through this brief test on students and looking at their qualitative responses, our team is even more convinced of the benefits of exposing students to PRWC, as it has the potential to elevate students’ awareness and deepen their appreciation of the application of mathematics to their daily lives.

CONCLUSION

Problem-solving skills, like soft skills, are intangible and sometimes very difficult to quantify. These skills take time to develop. Since our literature review has convinced us that the use of authentic contexts helps students to make connections to real life, our role as mathematics educators is to conscientiously expose our students to problems of diverse natures so that they are more prepared to take on the challenges in the 21st century and the VUCA world. As shown in the students’ responses, they enjoy the diversity and authentic nature of PRWC tasks. We need to believe in instilling the joy of learning through our daily practices and show persistence by exposing them to real-world problems, not just as individuals but as a fraternity.

Due to a lack of resources and skills, teachers find it difficult to design PRWC tasks. The conditioning of students towards solving computational mathematical problems and the lack of exposure to PRWC has also deterred many educators from making use of PRWC. The inability of students to handle PRWC tasks and their difficulty in analysing and solving such problems can also discourage teachers from exposing their students to PRWC.

The creation of the ICAE process aims to help teachers effectively design PRWC tasks using a structured thinking process. While it may take a longer time initially to be familiar with the process, mathematics teachers will find it fulfilling when they become more skillful in designing PRWC tasks. We hope that, as the teachers develop greater confidence in designing PRWC tasks, their awareness of and interest in real-world mathematics problems will increase. In the fraternity, as more PRWC tasks are designed and shared, teachers will consolidate their ideas and have more resources to draw upon when exposing students to PRWC tasks with diverse contexts and ideas. The final impact will be on students when they are able to appreciate the real-life relevance of and experience greater joy in learning mathematics, as well as find meaning and relevance in applying mathematical concepts to real-world problems. This will eventually lead to the strengthening of their critical thinking skills, developing them as independent learners who embrace lifelong learning.
REFERENCES


ABOUT THE CONTRIBUTORS

The authors are the members of a professional learning team (PLT) from Pasir Ris Secondary School. They have embarked on the journey of PRWC for the past 2 years, mainly embedding PRWC into lesson materials and designing PRWC tasks. The members of the PLT are of varied profiles, from beginning teacher to key personnel, all of whom made important contributions to the project. The leader of the team, Koh Kaddy, has been teaching Mathematics since 2004. His areas of interest are assessment and connecting authentic context to O–Level Mathematics concepts. His passion for connecting mathematics to the real–world context has prompted him to lead his PLT to conduct two sharing sessions on designing PRWC tasks in 2017 and one upcoming teacher–led workshop at the Academy of Singapore Teachers (AST) in 2018. Besides PRWC, he has also led PLT projects to promote critical thinking in the teaching and learning of Mathematics.
Engaging Students Using Quality Mathematical Tasks

Dr Radha Devi Oonnithan
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ABSTRACT

This paper aims to look at various forms of tasks and assignments that can be done in class as well as given as homework. Setting quality tasks and assignments for students is important as it could help them to understand or verbalise mathematical concepts using proper mathematical language and, in turn, acquire deep learning. Teachers need to decide on appropriate tasks based on the learning outcomes of the lessons that they plan to teach, so that students will find it meaningful when engaging in such activities. In this paper, two non-routine tasks that can be adopted at any secondary level are discussed.

INTRODUCTION

Students experience the joy of learning when they find meaning in what they are doing in class. Tasks and assignments given to them must be meaningful to their learning, and they should see themselves understanding concepts when engaging in such activities.

The purpose of an assignment is to help students improve their understanding of mathematical concepts and to practise skills. Assignments also act as formative assessments that help students better gauge their level of understanding of that particular topic. Unfortunately, students have a different perception regarding assignments. They often view an assignment as a task they should finish as quickly as possible without thinking deeply about what they are doing. Two studies (Trautwein, 2007 and Dettmers, Trautwein, Lüdtke, Kunter, & Baumert, 2010) have shown a positive correlation between high-quality assignment and mathematics achievement. Students who completed their assignments scored better on the Summative Assessment (SA). The same studies also showed, however, that time spent doing assignments had no significance on students’ achievement. Hence, educators should think carefully about the quality of assignments given to students, so as to ensure that students find them meaningful. Quality, and not quantity, of assignment matters.

Currently, questions in mathematics textbooks are categorised according to levels of difficulty. As educators, we tend to go through the easier questions in class, then set the more challenging questions to be done as assignments at home. This is when students feel frustrated. They might have understood the concepts in class and could have completed the class work as well. However, often, they are unable to complete their assignments due to the higher cognitive demand, especially without the guidance of the teacher. Hence, they tend to hand in incomplete or even copied work. Educators would then have to go through every single question in class so as to ‘ensure that the students understand’. In addition, while attempting questions, students must see themselves moving from one point to the next. They must taste success and improve as they do so. Only then will students value the tasks and assignments given to them. Hence, educators could consider giving bite-sized assignments which focus on the same learning targets as those in class. Students will then be able to see the connections to what they have learnt in class.

LITERATURE REVIEW

Tasks and Assignments

Selecting appropriate tasks and assignments to meet the learning outcomes of mathematics lessons is essential. Smith & Stein (1998) have emphasised that the highest learning gains for students result from engagement in high levels of cognitive thinking and reasoning. Tasks
and assignments can be broken down in terms of four categories of cognitive demand:
1. Memorisation
2. Procedures without connections to concepts or meaning
3. Procedures with connections to concepts
4. Doing Mathematics

The first two categories are considered ‘low level’ and, hence, have limited or low cognitive demand. As educators, we are highly encouraged to create tasks that fall under the third or fourth categories, which require deeper thinking and understanding of mathematical concepts.

**METHODOLOGY**

This paper focuses on two different tasks. These tasks can be used in class for whole-class discussions or as assignments, depending on the goals of the respective lessons.

**Find and Fix the Mistake**

Students are given examples of questions with wrongly worked solutions. They have to first read the solution to spot the mistake, then explain what is wrong using proper mathematical language and vocabulary. This requires students to have checked their understanding of the relevant concepts and also be able to apply them.

Four examples of questions with wrongly worked solutions are given in **Examples 1 to 4** below. In the examples, the questions are routine questions which students have done previously. However, using these questions in a non-routine manner captures students’ attention and motivates them to attempt the questions. Identifying the errors, explaining them using the correct mathematical vocabulary, then trying to solve the questions correctly, allows students to make connections to concepts that they have learnt and acquire a deep conceptual understanding.

**Example 1**

Solve the inequality

\[ x + 5 < 3x - 1 \]
\[ x - 3x < -1 - 5 \]
\[ -2x < -6 \]
\[ x < 3 \]

**Example 2**

Solve the equation

\[ (x - 1)(x + 1) = 15 \]
\[ x - 1 = 15 \text{ or } x + 1 = 15 \]
\[ x = 16 \text{ or } x = 14 \]

**Example 3**

Simplify \[ \frac{x^2 + 3x}{x^2 + 7x} \]

\[ \frac{x^2 + 3x}{x^2 + 7x} = \frac{3}{7} \]

**Example 4**

\[ \log_2(x - 3) + \log_2(x - 4) = 1 \]
\[ \log_2(x - 3) + \log_2(x - 4) = \log_2 2 \]
\[ x - 3 + x - 4 = 2 \]
\[ 2x - 7 = 2 \]
\[ 2x = 9 \]
\[ x = \frac{9}{2} \]

Such tasks allow students to identify errors which are often repeatedly pointed out by the teachers in class. Getting students to spot their own mistakes rather than telling them where the errors are would be more beneficial to their learning.

In a typical class, there are bound to be students who are able to solve procedural questions, but are unable to communicate their methods clearly. These students would rather follow the processes than understand and analyse the reasons for doing so. On the other hand, there are also students who face difficulties solving such procedural questions. When these non-routine tasks are administered, students learn to discover the errors on their own, to apply mathematical concepts confidently, and to take charge of their own learning. They also develop the skills to communicate and reason clearly.

From observations of the task administered to the study group, these wrongly worked solutions gave the students an opportunity to learn mathematics in a non-routine way, and many of them were willing to attempt the task.
The second type of task is focused on students creating their own word problems. In this assignment, students would write a story that matches a given diagram, expression, or equation.

Figure 1 shows a task on the speed-time graph. In this case, students are to create the context of the question that fits the given graph. To do this, they have to first understand and interpret the features of a speed-time graph before attempting to form a question. They also have to make sense of the units and values given and then link all the details together as a situation in real life. The demands of this task are much greater than those of the examples shown in the previous section. In this task, students need more time to think and contextualise the question.

When the task was given to the study group, most students were not prepared for such tasks, but were nevertheless pleasantly surprised. Since the level of cognitive demand was higher, some of the weaker students were a little hesitant at the beginning. They realised that they first had to be familiar with the characteristics of a speed-time graph, and they had to try to verbalise the mathematical concepts in the diagram to their classmates before trying to link the concepts meaningfully to real life. Through this activity, students became more aware of the concept of distance, and they began to have a better idea of what 50 km represents in real life.

For the task in Figure 2, some of the questions that were anticipated are as follows:

1. Sketch the graph of \( y = (x + 5)(x - 1) \)
2. Sketch the graph of \( y = (x + 2)^2 - 9 \)
3. State the minimum point / minimum value
4. State the equation of the line of symmetry
5. State the turning point and determine its nature
6. State the equation of the tangent at the minimum point
7. Solve \((x + 5)(x - 1) = 0\)
8. Find the discriminant of \( x^2 + 4x - 5 = 0 \)
9. Show that \( x^2 + 4x - 5 = 0 \) has two real distinct roots
10. Find the sum and product of the roots of the quadratic equation \( x^2 + 4x - 5 = 0 \)

These tasks were non-threatening, which motivated the slower and/ or weaker students to attempt them. The students even tried to explain the mistakes and solutions to their classmates.

Create Your Own Word Problem / Question and Solve It

The objective of this activity was to allow students to see the connections within and between topics. Students were encouraged to make connections to their prior knowledge. Such tasks allow educators to orchestrate productive mathematics discourse in class by adopting the five practices given by Smith & Stein (2011), namely, Anticipating, Monitoring, Selecting, Sequencing, and Connecting.

Anticipating requires educators to anticipate the different ways the mathematical tasks can be solved. This requires one to consider how students might interpret a problem mathematically and what strategies they might use to solve it. Monitoring student responses involves paying close attention to students’ responses, solutions, and strategies while moving around the class. Educators would then have to decide on a selection of students’ work, and the sequence in which this work is to be presented. This would make it easier for students to see the connections between the topics, units, strategies, and concepts.
Generally, students were not able to form Questions 8 to 10. One possible reason could be that they had not been exposed to such scenarios. During discussion, students were able to understand and appreciate the connections between topics and concepts in Additional Mathematics and Elementary Mathematics. They were able to connect, communicate, and reason key concepts with their classmates.

CONCLUSION

Throughout my career, I have been looking at different ways to engage my students in class and out of class. Giving them quality tasks and assignments has always been the topmost priority on my list. I believe that every child can learn and wants to do well. As educators, we could try to be more creative in our teaching and assign tasks which students will find meaningful in attempting.

Being able to identify mistakes in a given solution allows students to think about and analyse both the problem and the solution. They need to understand, recall, and apply mathematical concepts, and articulate them using proper mathematical language and vocabulary when communicating with their peers. Forming mathematically sound questions allows students to think about and analyse each topic that they have learnt. In this process, students are able to reflect on and see the connections between topics that they have learnt. Both tasks allow students to make learning visible to themselves. In addition, in the process, they see themselves improving and, hence, moving from one point to the next.

As educators, we must be aware of the purpose of our actions in class. The task or assignment given must be able to meet the learning outcome of the lesson. We have to prepare our students for the future – a VUCA (Volatile, Uncertain, Complex, and Ambiguous) world – and not just for examinations. We need to nurture our students to be self-directed learners who are able to process information, think creatively, work in teams, and communicate effectively. Our classrooms must be safe places where mistakes are welcomed. For this to happen, we need to think about our teaching, modify our lessons, and assign quality tasks so that they bring out the joy of learning in our students.

REFERENCES


ABOUT THE CONTRIBUTOR

Dr Radha Devi has been teaching mathematics for 20 years. Being a Lead Teacher, she is passionate about active learning and mathematical knowledge for teaching. She looks into designing quality tasks for the students, Assessment for Learning strategies and Flipped Learning. She believes that every student can learn and wants to learn regardless of the entry point. Every student, being different, will need different ways to learn. Being interested in the professional development of teachers, she leads Networked Learning Communities and shares her work with the fraternity on several platforms. She has presented her insights at both national and international conferences.
Mathematical Modelling (MM) is a process of representing or describing real-world problems or situations in mathematical terms in an attempt to find solutions to the problems or to gain a better understanding of the real-world situation (see Figure 1).

In the new 2013 Ministry of Education (MOE) syllabus for Mathematics, the mathematics framework includes modelling as a key component of the process of learning. Applications and modelling allow students to connect mathematics to the real world, thus enhancing their understanding of mathematical concepts.

When designing the Mathematics Modelling (MM) task, the teachers wanted students to have more learning experiences, and the ‘Packing Problem’ appeared to have the most potential. This is because the concept of packing is common knowledge to most students, and they are able to use empirical data to verify the model. In addition, a set of holistic assessment rubrics (using modelling perspectives) was designed to assess the MM task. The components of the assessment rubrics were: mathematical insight, mathematical reasoning, contextual effectiveness of solution, accuracy of work, and quality of communication.

Solving real-world problems directly is very challenging, and mathematical modelling acts to scaffold the solution process. Through MM, the model can be used to:
- predict future trends or behaviour;
- design, propose, or construct things and/or systems; and
- explain and understand some real-world situation.

**ABSTRACT**

In the new 2013 Ministry of Education (MOE) syllabus for Mathematics, the mathematics framework includes modelling as a key component of the process of learning. Applications and modelling allow students to connect mathematics to the real world, thus enhancing their understanding of mathematical concepts.

When designing the Mathematics Modelling (MM) task, the teachers wanted students to have more learning experiences, and the ‘Packing Problem’ appeared to have the most potential. This is because the concept of packing is common knowledge to most students, and they are able to use empirical data to verify the model. In addition, a set of holistic assessment rubrics (using modelling perspectives) was designed to assess the MM task. The components of the assessment rubrics were: mathematical insight, mathematical reasoning, contextual effectiveness of solution, accuracy of work, and quality of communication.

**INTRODUCTION**

**Mathematical Modelling**

Mathematical Modelling (MM) is a process of representing or describing real-world problems or situations in mathematical terms in an attempt to find solutions to the problems or to gain a better understanding of the real-world situation (see Figure 1).

In the new 2013 Ministry of Education (MOE) syllabus for Mathematics, the document explained that learning mathematics is a key fundamental in every education system that aims to prepare its citizens for a productive life in the 21st century. The mathematics framework includes modelling as a key component of the process of learning, and MM is part of the Mathematics syllabus from the lower secondary to junior college levels. Applications and modelling allow students to connect mathematics to the real world, thus enhancing their understanding of mathematical concepts.

Solving real-world problems directly is very challenging, and mathematical modelling acts to scaffold the solution process. Through MM, the model can be used to:
- predict future trends or behaviour;
- design, propose, or construct things and/or systems; and
- explain and understand some real-world situation.

**BACKGROUND**

MM was first introduced to the Year 2 cohort in Dunman High School in 2014. The teachers were ambitious and rolled out two MM problems as part of alternative assessment - the ‘Water Problem’ and the ‘Drain Problem’. In the ‘Water Problem’, students were to determine if Singapore could be self-sufficient in her water supply should Malaysia stop...
supplying Singapore with water. The ‘Drain Problem’ looked at determining the best drain design to ensure a good flow of flood water, thus reducing flooding in Singapore. Taking into account the feedback of students and teachers, only the ‘Water Problem’ was given to the Year 2 cohort in 2015. However, the students still found MM daunting and too theoretical. In 2016, in designing the MM task, the teachers wanted students to have more learning experiences, and the ‘Packing Problem’ appeared to have the most potential. This is because the concept of packing is common knowledge to most students, and they are able to use empirical data to verify the model. In the ‘Packing Problem’, students had to determine the box, made from an A5-sized sheet of cardboard, that could hold the maximum number of marbles.

Another change made in the alternative assessment project was in the type of assessment. Previously, traditional assessment was used, where students followed the rubrics to answer the questions. However, we found that, when students used the criteria to guide them in their answers, there was a lack of higher-order thinking involved (Lesh, Lester, & Hjalmarson, 2013). A set of holistic assessment rubrics (using modelling perspectives) was designed to assess the MM task. The components of the assessment rubrics were: mathematical insight, mathematical reasoning, contextual effectiveness of solution, accuracy of work, and quality of communication. This shift towards a more process-oriented instruction and assessment implies a change in teachers’ and students’ dispositions towards what is valued as important in the mathematics classroom (Carpenter & Lehrer, 1999). Moreover, the reflection component of the MM task focused on metacognition to promote thinking about their own thinking in students. In particular, the question prompts sought to get students to think about their metacognitive knowledge of MM (Flavell, 1976).

The MM task was done mainly on Google Sheets and Google Docs. The teachers had the flexibility to request hard copies for the written report. The peer evaluation was conducted using Google Forms. The use of ICT improved efficiency and enabled many groups to work online without having to meet face to face. In addition, students were able to take photos of their experiments of packing marbles into the boxes and embed the photos in the report. This was convenient for the students and enabled them to save time. In total, three 1-hour periods of curriculum time were allocated for the MM task.

METHODOLOGY

Crafting the MM task

Time-Tabled Time (TTT) was utilised to plan the task. Based on the previous experiences of conducting MM, the team of teachers intentionally crafted the task to increase students’ experience with the MM process. We brainstormed many ideas and finally decided on crafting a new problem, the ‘Packing Problem’, instead of using the ‘Water Problem’. After the MM task was drafted, with lots of input and refinement, it was decided that the assessment of the MM task should be holistic so as to make the shift from assessing the product to assessing the process of learning. This is particularly important to MM as there is no one definite answer to any MM problem, and both teachers and students need to make the shift to accepting multiple solutions. A full overview of the lesson, with plans, was written to guide the team in the execution of the alternative assessment of the ‘Packing Problem’.

Executing the MM Lesson

The ‘Packing Problem’ comprised two parts. Part 1a of the MM task was a worksheet to guide students in learning to use Excel on their own. To promote independent learning, YouTube videos were uploaded and used to help students grasp the basic skills required in using Excel. In Part 1b, students, in groups (of not more than four), were tasked to determine the maximum volume of a box made from a sheet of A5-sized cardboard. Using the Excel spreadsheet, students had to create a table listing the values of the length, breadth, and height of the box, and draw a graph of Volume against Height. Students then used the mathematical concept of the turning point to determine the dimensions of the box with the maximum volume. The students were given a week to complete both Parts 1a and 1b.

After the teachers had assessed the students’ reports, Part 2 of the task was then given to the students. By assessing the first part of the report, the teachers were able to check for understanding, and that all students knew the dimensions of the box with the maximum volume. This enabled all students to build on the correct concept for the next part of the task.

Part 2 of the task required students to go online to conduct research on the two methods of packing spheres into a box: simple cubic and hexagonal. Each group was then assigned specific dimensions for a box and the students were tasked to find the maximum number of marbles...
the box could hold. The groups were able to calculate the theoretical value of this number. Following this, each group constructed its own box and brought it to the next lesson, at which groups would conduct an experiment to determine the maximum number of marbles the box could hold (see Figure 2). All the data of each group in the cohort was compiled in an Excel spreadsheet and shown to the cohort. Based on the cohort data, each group was to determine if the box with maximum volume would hold the maximum number of marbles. Students had to submit their group reports by the end of Term 3 Week 10. Altogether, alternative assessment of the MM task spanned a period of 4 weeks.

Peer evaluation was conducted among the students. Students who did not do the peer evaluation would obtain zero marks for peer evaluation. This was effective in differentiating between the contributions of each group member. Students who contributed more obtained higher marks for peer evaluation, and those who did not contribute as much were likely to obtain one grade lower.

**Assessment of Learning**

At the beginning of the first lesson, the teachers surveyed the students to find out how many had watched the video on how to use the Excel spreadsheet. It was found that, on average, 30% of the students had watched the video. Teachers needed to provide more support.

The teachers moved around the class during group work to observe students’ level of engagement, monitor their progress, and provide the necessary feedback to help students complete the task. Teachers would observe students’ behaviour to determine if they were able to conduct the experiment with minimum support. The written reports were assessed to determine the accomplishment of the MM task. Benchmarking was carried out to ensure consistency in the assessment of the students’ reports.

**Review of the MM Task**

During TTT, the teachers discussed the progress of the students and the type of guidance they required to ensure that they were able to complete the task. The teachers also evaluated the MM task.

**Incorporation of Cooperative Learning**

Akinbobola (2006) defined cooperative learning as a mode of learning in which students of different abilities work together in small groups to achieve a purpose. It is a student-centred, not teacher-centred, approach.
In groups, students interact with one other, share ideas and information, seek additional information, and make decisions (Kort, 1992). Johnson & Johnson (1989) found that cooperative learning fosters creative thinking, and students in a group generate new ideas, strategies, and solutions, which are more powerful than those generated in individual learning.

The team also incorporated Bruner’s (1961) theory of discovery learning into the students’ group activity of determining the arrangement of marbles that maximise the space in the box, where the students worked in mixed-ability groups. Bruner defined discovery learning as the learning that takes place when students are not presented with subject matter in its final form, but are instead required to organise it themselves. Since this activity was carried out in groups, the students had a lot of opportunities to discuss, construct mathematical concepts, clarify misconceptions with one another, and think of creative ways of solving the problem.

**Evaluation**

The Year 2 Mathematics teachers met during TTT to benchmark the students’ work. Part 1b was relatively straightforward and the rubrics were clear to the students. However, many groups were unable to provide a good title for the graph and did not add the headings for the Excel spreadsheet. We found that the spreadsheets had some limitations in terms of annotation. For example, students were not able to insert the heading for the page. Apart from this, as the students were able to know the marks they had been awarded in Part 1b, those who did not do as well were encouraged to do better in Part 2.

For Part 2, six sets of students’ work (of high, medium, and low ability) were duplicated for each teacher for the benchmarking of the MM reports. Three TTT sessions were used to conduct the benchmarking and for teachers to gain an understanding of what constituted students’ mathematical insight, mathematical reasoning, contextual effectiveness of solution, accuracy of work, and quality of communication. The time devoted to the session proved to be more meaningful for the teachers and enabled them to know what to look out for to determine if students had some mathematical insight. Descriptors were added to the rubrics for assessment of students’ learning in terms of process rather than product. For example, for mathematical insight, the focus was on mathematical concepts and understanding. This was generally concerned with students’ depth of thought (specifically related to mathematics) and understanding (of concepts and of the problem), both of which affect the quality of their responses. For example:

• Recognising and making correct links between information, calculations, and observations from different sections;
• Noting the effect of height on the number of layers of marbles;
• Noting a different arrangement of marbles in the second layer;
• Correctly deciding to round down answers in calculations (where applicable).

**CONCLUSION**

**Key Learning Points**

The written report required in Part 2 and the students’ metacognitive reflections were very useful in helping the team gain great insights into students’ understanding of the mathematical concepts. Peer evaluation data gave teachers insight regarding the level of engagement and contributions of the students in the group, group dynamics, values learnt in group work, and students’ attitudes towards mathematics. In addition, the use of the student-centred approach of activity-based lessons increased the level of the students’ engagement in the Mathematics classroom. Students preferred this style of teaching to the type of teaching that was heavily dominated by teachers and hardly involved any hands-on activities.

In addition, the use of discovery learning and group work strategies in the Mathematics lesson promoted teamwork, communication, investigation, discussion, peer-teaching, and problem-solving among students, as well as increased students’ level of engagement.

Based on the feedback of the students, most were able to complete the MM task and knew what was expected of them. The holistic assessment appeared to be effective in guiding students to accomplish the MM task. In particular, the holistic assessment rubrics (Appendix 1) were effective in assessing the process of learning. The students did not aim to obtain one correct answer but tried to demonstrate their understanding. Teachers had communicated clearly to the students that there was a shift in the focus of assessment to the process instead of the product.
As the reflection was considered a ‘bonus’ question (Appendix 2), less than half of the cohort completed the reflection on the alternative assessment. The reflections were benchmarked to ensure consistency in assessment. Those that did not highlight mathematical understanding of concepts were awarded only one mark, while those that demonstrated some understanding of the mathematical concepts involved in solving the ‘Packing Problem’ were awarded the full two marks.

**Recommendations**

Metacognition, or thinking about thinking, refers to the awareness of and the ability to control one’s thinking processes, in particular, the selection and use of problem-solving strategies. It includes the monitoring of one’s own thinking, and self-regulation of learning. (MOE, 2013, p. 17)

As the MM task was given near the end of Term 3 (which was rather late), the teachers felt that the reflection should be made optional and be awarded as ‘bonus’ marks. However, the team recommended that all students in future should do the reflection in order to promote metacognition. The reflection would enable students to be aware of the process of their own learning, thus encouraging them to focus more on this process and not only on getting the right answer.

During the review of the ‘Packing Problem’ at the Math Workplan, the Professional Learning Team highly recommended that the 2017 team of Mathematics teachers continue with the ‘Packing Problem’. In doing so, more data could be collected on the holistic assessment rubric. In particular, an analysis of the reflections by the students will enable teachers to gain insights into the students’ process of learning during the MM task.

**REFERENCES**


ACKNOWLEDGEMENT

We thank Dr Leong Swee Ling for her guidance and being the Mentor of this project.

ABOUT THE CONTRIBUTORS

Low Siok Hong enjoys reading about the history of mathematics and the application of mathematics concepts in real life, as well biographies of mathematicians. Her passion is to make mathematics alive in the classroom. She holds a Master of Education (2016) and her dissertation was on the effect of activity-based lessons on mathematics achievement of Secondary Two students. She also led a team to present a paper entitled “Are activity-based lessons effective in increasing the level of engagement of students in learning mathematics?” at the International Education Conference 2016 in Italy.

Tan Lee Hwee has been involved in studying the use of Productive Failure and Mathematical Modelling in the teaching and learning of lower secondary Mathematics since 2006. Over the years, he has helped in organising several workshops and seminars for students by the Gifted Education Branch. His current interest lies in how teachers can utilise alternative forms of teaching like ICT and manipulatives to enhance the mode of delivery of lessons.

Tan Hui Ming Elizabeth was the Year 2 Mathematics Coordinator in DHS in 2017. Her interest lies in the application of mathematics in a real-world context.

Ho Hwee Ling was the Subject Head of Mathematics in DHS. She is interested in infusing authentic performance tasks into the Mathematics curriculum to enhance students’ learning experience.
## Appendix 1: Rubrics for Year 2 Mathematics Project on the ‘Packing Problem’ (Part 2)

<table>
<thead>
<tr>
<th>Name (Register No.)</th>
<th>Class</th>
<th>Group No.</th>
<th>Approaching Expectations</th>
<th>Meeting Expectations</th>
<th>Exceeding Expectations</th>
<th>Mark Awarded</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Mathematical Insight</strong></td>
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<td></td>
<td></td>
<td></td>
<td>Barely able to grasp the essence of the problem and apply the appropriate concepts to solve the problem.</td>
<td>Able to grasp the essence of the problem and apply the correct concepts to solve the problem.</td>
<td>Going well beyond the grasp of the problem and applying the correct concepts to solve the problem.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Mathematical Reasoning</strong></td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Shows a logical plan to solving the problem. The approach, justification, and answers are clear.</td>
<td>Shows a methodical, logical plan to solving the problem. The approach, justification, and answers are explicit.</td>
<td>Shows a methodical, logical and thorough plan for solving the problem. The approach, justification, and answers are explicitly detailed and reasonable throughout.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Contextual Effectiveness of Solution</strong></td>
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<td></td>
<td></td>
<td></td>
<td>The solution was reasonable and can be applied to the real-world context.</td>
<td>The solution was reasonable and can model the real-world context.</td>
<td>The solution is the best for the given problem.</td>
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<td></td>
<td></td>
<td></td>
<td><strong>Accuracy of Work</strong></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Work is accurate, 80% of calculations are correct, provided to the proper degree of accuracy, and properly annotated.</td>
<td>Work is accurate, 90% of calculations are correct, provided to the proper degree of accuracy, and properly annotated.</td>
<td>Work is accurate, all calculations are correct, provided to the proper degree of accuracy, and properly annotated.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Quality of Communication</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Write-up is presented with some missing pictures. The essence of the problem solved could have been summed up in a concise and efficient manner.</td>
<td>Write-up is properly presented and all pictures are included. The essence of the problem solved is summed up in a concise and efficient manner.</td>
<td>Write-up is well presented and all pictures are included. The essence of the problem solved is summed up in a highly concise and efficient manner.</td>
<td></td>
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</tbody>
</table>

<table>
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<tr>
<th>Total Group Mark</th>
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<table>
<thead>
<tr>
<th>Bonus (Individual Mark)</th>
<th>Total Individual Mark for Part 2</th>
</tr>
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<tbody>
<tr>
<td>subjected to max. 15 marks</td>
<td></td>
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</tbody>
</table>
Appendix 2

<table>
<thead>
<tr>
<th>Name (Register No.)</th>
<th>Class</th>
<th>Group No.</th>
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<tbody>
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Bonus Section – Individual Metacognitive Reflection [2 marks for individual]

With reference to the Mathematical Modelling process you have just experienced, answer up to two metacognitive questions below. Indicate your choice by ticking the box next to it.

- You have the option to craft your own metacognitive question, but it must be relevant to the mathematical modelling process.
- Support your answers by including examples or counterexamples.
- Maximum word count is 150.

☐ What was the Math problem all about?
☐ What difficulties did I have?
☐ What would I like to know more about with respect to the ‘packing problem’?
☐ What is another method of solving the same problem?
☐ What are some mathematical ideas that are interesting to me?
☐ Own question: ________________________________________________________________
**A Science Inquiry-Based Flipped Classroom**

**ABSTRACT**

Leveraging on technology, a Science inquiry-based Flipped Classroom provides a flexible learning environment for students to construct knowledge, clarify doubts, and collaborate with their classmates. Flipped learning allows students to seek clarification in class with their teachers as facilitators and to revisit concepts at their own pace. Through inquiry-based learning, students learn through their mistakes and, hence, self-directed and independent learning take place in the classroom. Students are highly engaged as new knowledge connects with their prior knowledge.

With the use of Edpuzzle for self-directed learning, students watch videos, in which quizzes are embedded, at their own pace. They will learn beyond the curriculum, identify their own mistakes, reflect on their learning, and use feedback to improve on their work.

With the use of PhET Interactive Simulations, self-directed learning takes place as students work independently, take charge of their own learning, and manage their own progress. It allows students to grasp concepts more easily due to the interactive exercises.

With the use of NearPod, collaborative learning is carried out, where students contribute ideas and set common goals. Appropriate and timely constructive feedback is provided to improve students’ learning and to clarify misconceptions of the scientific concepts learnt.

**INTRODUCTION**

In this article, teachers will be able to recognise the benefits of facilitating an inquiry-based Flipped Classroom for students to construct knowledge, clarify doubts, and collaborate with their classmates. Teachers will be able to find out how ICT tools (Edpuzzle, PhET Interactive Simulation, and NearPod) can be used effectively for inquiry-based learning and to assess students’ understanding. Through the use of the ICT tools, learners are given opportunities to develop the skills, habits of mind, and attitudes necessary for scientific inquiry. Learners are provided with experiences which promote curiosity and critical thinking to develop their sense of inquiry. The platforms provide a safe and engaged learning environment to encourage active participation through self-directed and collaborative learning. More importantly, inquiry-based learning often relates to authentic contexts. Thus, learning is meaningful and useful as learners make connections to their daily lives.

**THE C³ OF FLIPPED LEARNING**

According to Brian Bennett, “The Flipped Classroom isn’t a methodology. It’s an ideology.” (as quoted in Tully, 2014). There is no specific method of carrying out a flipped lesson. A teacher can adapt different methods and strategies to be used in a Flipped Classroom. A Flipped Classroom is fluid and adaptable and, when done correctly, a flipped lesson will have a positive impact on students’ learning. Leveraging on technology, a Flipped Classroom provides a flexible learning environment for students to construct knowledge, clarify doubts, and collaborate with their classmates. These are the three ‘C’ s of a Flipped Classroom.
Construct Knowledge

Students are able to:
- learn in a learner-centred model where educational technologies such as online videos are used to deliver instructional content outside of the classroom;
- watch online videos and lectures at home at their own pace and repeatedly if necessary;
- carry out their research at home; and
- acquire and construct knowledge as they participate in activities and evaluate their own learning.

Clarify

Students are able to:
- receive immediate feedback to increase their understanding and motivation;
- easily revisit concepts that they do not understand; and
- clarify doubts and misconceptions easily as the teacher’s interaction with students is personalised.

Collaborate

Students are able to:
- engage in and collaborate via online discussions with their classmates and the teacher about the concepts presented in the videos;
- complete learning activities in the classroom during the day. As shown in Figure 1, homework that was issued in a traditional classroom will be completed as a learning activity in a Flipped Classroom. Learning activities are usually completed as a team to allow self and peer assessment to take place;
- explore topics in greater depth and create meaningful learning opportunities during class time;
- engage in different types of active learning, which allows for highly differentiated instruction; and
- tackle difficult problems, work in groups, conduct research, and construct knowledge with the help of their teacher and peers. More time can be spent in class on higher-order thinking skills such as problem finding, collaboration, design, and problem solving.

EDpuzzle

EDpuzzle is a simple and free ICT tool for teachers to create videos in which quizzes are embedded, a very important aspect of the Flipped Classroom. With EDpuzzle, a teacher will be able to search for videos from YouTube or other sources and upload them. As shown in Figure 2, quizzes can be embedded in videos at appropriate junctures for self-assessment. As EDpuzzle has a feature that prohibits the skipping of videos, accountability is reinforced as teachers are able to ensure that students complete their assigned tasks using the information provided, as shown in Figure 3. Besides assessing students’ work, teachers are able to monitor students’ progress and use the information provided to modify the next lesson to suit their learning needs, as shown in Figures 4 and 5. With the use of EDpuzzle, students will be able to apply self-directed learning through setting their own goals, making decisions, and managing their own workload. Students will be able to learn beyond the curriculum, self-assess and reflect on their own learning, and use feedback to improve on their work. EDpuzzle engages students easily by building upon prior knowledge through highly interactive lessons and, hence, learning is self-paced and self-directed.
Figure 2: Sample of a Quiz embedded in an EDpuzzle Video

Figure 3: Progress Monitoring of Class
Figure 4: Individual Grading

Figure 5: Progress Monitoring of an Individual Student
Interact with PhET Interactive Simulations

PhET Interactive Simulations is a free, user-friendly, and interactive ICT tool that makes lessons come alive. It allows students to explore scientific concepts in topics such as electrical systems and magnets. It supports inquiry-based learning and increases student engagement as students are able to engage in hands-on and interactive experiences with virtual bulbs, switches, batteries, and magnets. For example, students are able to find out the effect of a short circuit as shown in Figure 6, and the effect of too much current, resulting in blown bulbs, as shown in Figure 7. Hence, students are able to explore concepts related to electricity safely at zero cost. Students are able to receive immediate feedback through the interactive simulations, and misconceptions can be cleared up in a timely manner. PhET Interactive Simulations encourages the deeper learning of scientific concepts and helps to build students’ resilience as students persevere through making mistakes.

Figure 6: Short Circuit in an Electrical Circuit

Figure 7: Too much Current in an Electrical Circuit
NearPod is an ICT tool used to facilitate Assessment for Learning (AfL) through Visible Thinking. NearPod can be used in the classroom during learning activities to increase student engagement and collaboration as a team. It helps to engage students through real-time questioning where instant feedback can be provided. Teachers are able to create their own assessments, customise content for each lesson based on students’ needs, and use the assessment data provided to assess if learning has taken place.

Interactive classes can easily be created by uploading a PowerPoint presentation and then adding interactive features according to the needs of the students or the objectives of the lesson. The multimedia content captures students’ attention and interest, ensures their participation, and keeps them engaged in and focused on the lesson. NearPod allows teachers to observe classroom activities and monitor and control students’ devices, hence minimising off-task behaviours. It is easily accessible through desktops, laptops, iPads, or smartphones, anytime and anywhere.

NearPod has many features for sharing content and conducting real-time assessments, such as polls, quizzes, web content, fill-in-the-blanks activities, open-ended questions, drawing boards (Draw It), collaborate boards (Figure 8), and memory games. At the end of each lesson, the teacher can generate a NearPod post-session report as a form of AfL to keep track of the students’ learning, as shown in Figure 9. This will be useful in planning for the following lesson. In this way, teachers will be able to monitor students’ learning to provide immediate constructive feedback.
CONCLUSION

With the use of technology in the classroom, 21st century competencies will be developed and student learning outcomes will be achieved as students learn how to communicate and collaborate confidently and think critically. Moving on to ICT Masterplan 4, the change in mindsets of stakeholders, such as students, teachers, and parents, is essential yet challenging. Stakeholders need to have a mindset shift in order that flipped learning may be carried out successfully with the extensive use of ICT tools.

Worksheets as homework may not be required any longer as knowledge construction is done at home and clarification and collaboration are done in the classroom. Schools’ Wi-Fi infrastructure needs to be able to support the large number of devices logging onto the network concurrently. Furthermore, schools need to have sufficient iPads and/or laptops for students to have one-to-one computing in order for collaborative learning to take place effectively.

REFERENCES


ABOUT THE CONTRIBUTOR

Tan Chay Tin Jasmine, Head of Department - Character and Citizenship Education of CHIJ (Katong) Primary, has been teaching Science for 10 years in the school. She is passionate about the use of information technology in her teaching in order to increase student engagement levels and to assess students’ learning through Visible Thinking and Assessment for Learning. She is an advocate of inquiry-based learning in Science and contributes to the fraternity as an E2K teacher trainer. She has conducted many sharing sessions on promoting the use of information technology in lessons to bring about the joy of learning and to make lessons come alive.
Assessing Misconceptions Using 3–Tiered Multiple–Choice Questions and Thinking Routines

Yap Chong Chieh
Ahmad Tarmidzi Bin
Mohammad Kassim
Eunos Primary School

ABSTRACT

Assessment is an important process in feeding student learning forward. However, the most common and easiest forms of assessment in schools, such as using multiple-choice questions (MCQ), may not offer deep insights into students’ understanding of concepts. Our action research project aims to explore how existing Assessment for Learning (AfL) MCQ tasks can be modified to shed more light on students’ understanding and misconceptions in science. In this project, a 3–tiered MCQ test was administered for the following topics: the digestive system, photosynthesis, and the human circulatory system. Each test consisted of at least three multiple-choice questions. For each question, students chose the correct option and wrote down the reason for their answers. They then rated their confidence level for the question on a Likert 5–point scale. A framework was subsequently used to analyse student responses to determine the depth of understanding of concepts taught in class. The framework looked at (1) whether the students answered the item correctly, (2) whether the students decoded the question correctly based on the reasons given, and (3) the students’ level of confidence in the answer they provided for the item. The information obtained from the analysis of the tests, as well as written explanations from students, provided teachers with a clear direction in addressing students’ difficulties with the topics.

INTRODUCTION

Assessment is important in feeding–forward learning. However, the most common and easiest forms of assessment used in schools, such as the multiple–choice question (MCQ), do not offer deep insights into students’ understanding of science concepts. In this research project, we will attempt to improvise and tweak the existing MCQ structure to allow it to be more informative for the teachers. Our action research project aims to explore how existing Assessment for Learning (AfL) tasks that are often heavily reliant on the MCQ format can be modified to shed more light on students’ understanding and misconceptions in science.

BACKGROUND

The research idea came about after the authors attended a course on conducting action research in school. The research question posed was: How can we use existing multiple–choice questions to reveal more information about students’ learning? We felt that this was best achieved by using a tiered MCQ approach.
Effective instruction and formative assessment are essential components in teaching and learning and can raise students’ achievement (Biggs, 2003; Black & William, 2010). However, the type of feedback given in assessments has a direct impact on student learning (Hattie & Timperley, 2007).

Assessment strategies and modes also impact students’ emotions and attitudes towards learning. To foster intrinsic motivation in learning and to help lower-progress students to achieve, assessment strategies need to balance traditional and alternative approaches to the evaluation of student performance (Vonderwell & Boboc, 2013). In addition, the effective use of formative assessment also promotes self-regulation in student learning (David & Debra, 2006).

Anxiety is also a factor that affects student performance on an assessment. In their research, Mandler & Sarason noted that anxiety present in the test condition is an important variable in test performance (Mandler & Sarason, 1953). The confidence students have in the topic of study also plays an important role as it determines their performance on the test. It was noted that students with high levels of confidence in the subject and those with low levels of confidence in the subject differed very little in their interactions with the teachers (Hart, 1989).

Formative assessment can also provide teachers with the evidence with which to diagnose potential problems with their instruction, allowing teachers to improve the teaching and learning process (Gibbs & Simpson, 2005; Marks, 2014).

Based on the existing literature, there are opportunities for us to find out how the tiered MCQ format will impact formative assessment, as well as how it can improve feedback given to students.

In this project, a 3-tiered MCQ utilising a confidence-interval and explanation-elicitation format was administered for the following topics: the digestive system, photosynthesis, and the human circulatory system. This was to replace the existing pop quiz, consisting of four MCQs and an open-ended question, administered to students at the end of every topic. The revised test consisted of three questions with hinge questions embedded that would enable us to determine if students had gained a reasonable level of understanding. The design flow was such that the test would be administered once a lesson had been carried out before moving on to the next lesson (Figure 1). We believed that the testing would give the teacher sufficient input as to whether there was a need to revisit the topic.

The test consisted of at least three MCQs administered either on paper or through an online learning platform, Nearpod. The questions selected for the test were based on the table of specifications for the current topic and could be from practice papers that covered the testing of the hinge questions for the topic. For each question, students wrote down their chosen option. They then rated their confidence level for the question, and, lastly, gave a reason as to why they chose that option. The figure below shows a sample of a question (Figure 2). After the pop quiz had been administered, the teachers would then collate the results and determine if they should revisit the topic based on the possible misconceptions uncovered.
A framework designed by the team was then used to analyse student responses to determine the depth of understanding of concepts taught in class. The framework looked at the following aspects from the students' responses:

- Whether the item was answered correctly;
- How much confidence students showed in their answers provided for the item; and
- If there were any errors in decoding the questions based on the elaborations given.

Based on the students’ responses, the teacher could then classify students into eight different groups using the framework (Figure 3). The placement of students in each group would be based on the students’ answers, their confidence levels, and how they decoded that particular question. The framework analysis was repeated for each student as many times as there were MCQs.

In each group, there were also suggested remediation strategies to close the students’ learning gaps (Figure 4). The categorisation of students based on the results analysis could also provide the teacher with an overview of the class learning progress.

**What was the reason for your answer?**

Figure 2: Sample of a Test Question

Figure 3: Analysis Framework for Classifying Students

<table>
<thead>
<tr>
<th>Possible Actions for each Group</th>
<th>Answers correctly</th>
<th>Answers incorrectly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confident, Decodes correctly</td>
<td>NA, can progress to another item</td>
<td>Attempt another question that tests the concept to check for understanding</td>
</tr>
<tr>
<td>Not confident, Decodes correctly</td>
<td>NA, can progress to another item</td>
<td>Attempt another question that tests the concept to check for understanding</td>
</tr>
<tr>
<td>Confident, Decodes incorrectly</td>
<td>1. Go through question and scaffold comprehension of question.</td>
<td>1. Go through question and scaffold comprehension of question.</td>
</tr>
<tr>
<td></td>
<td>2. Attempt another question of similar structure (e.g. experimental setups / graph).</td>
<td>2. Attempt another question of similar structure (e.g. experimental setups / graph).</td>
</tr>
<tr>
<td>Not confident, Decodes incorrectly</td>
<td>1. Go through question and scaffold comprehension of question.</td>
<td>Pull out to reteach concept and go through question.</td>
</tr>
</tbody>
</table>

Figure 4: Possible Actions for each Category of Students
In order to determine the effectiveness of the tiered MCQ, a comparison was carried out between the first two tests administered to the class. After the first test, students’ answers were categorised into the various groups and then compared with another test taken later with the same test format. The tests were on different topics, as it was not possible to repeat the same type of test over two sessions due to the curriculum schedule. In the comparison below, we wanted to see if the experience of the first tiered MCQ test had reduced the number of students who answered questions correctly due to pure guesswork on the second test. This would be represented by the categories where students are ‘confident but decoded incorrectly’, and ‘not confident and decoded incorrectly’. Responses thus categorised are bolded and underlined in Table 1 below.

### RESULTS

Table 1: Comparison of Test Results for P5 Class (1st Trial)

<table>
<thead>
<tr>
<th></th>
<th>P5 Test 1 (n = 23)</th>
<th>P5 Test 2 (n = 23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct Answer</td>
<td>Wrong Answer</td>
<td>Correct Answer</td>
</tr>
<tr>
<td>Confident and decoded correctly</td>
<td>9.8%</td>
<td>3.2%</td>
</tr>
<tr>
<td>Not confident but decoded correctly</td>
<td>44.3%</td>
<td>8.7%</td>
</tr>
<tr>
<td>Confident but decoded incorrectly</td>
<td>13.0%</td>
<td>18.5%</td>
</tr>
<tr>
<td>Not confident and decoded incorrectly</td>
<td>10.9%</td>
<td>31.6%</td>
</tr>
</tbody>
</table>

The comparison, as shown in Table 1, is for a low-progress Primary Five (P5) class consisting of 26 students. For both tests, there were 3 absentees. There were 4 MCQs on Test 1 and 3 on Test 2. We observed that the total percentage of students who answered the questions correctly through guesswork saw a slight drop between the tests, from 23.9% (13.0% + 10.9%) in Test 1 to 15.9% (5.8% + 10.1%) in Test 2. This could imply that students were more careful with their answers and took a bit more time to think through them before they wrote them down. This was evident in the detail and quality of their explanations on Test 2, where there was an increase in students’ effort to write down their reasoning for their answers.

In addition, more questions were decoded correctly on Test 2, from 26% of the total responses on Test 1 to 50.6% of the total responses on Test 2. This suggests that students made more effort in decoding and applying critical thinking skills to the questions.

Table 2: Comparison of Test Results for P3 Class (1st Trial)

<table>
<thead>
<tr>
<th></th>
<th>P3 Test 1 (n = 33)</th>
<th>P3 Test 2 (n = 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct Answer</td>
<td>Wrong Answer</td>
<td>Correct Answer</td>
</tr>
<tr>
<td>Confident and decoded correctly</td>
<td>33.3%</td>
<td>12.1%</td>
</tr>
<tr>
<td>Not confident but decoded correctly</td>
<td>24.2%</td>
<td>6.1%</td>
</tr>
<tr>
<td>Confident but decoded incorrectly</td>
<td>3.0%</td>
<td>9.1%</td>
</tr>
<tr>
<td>Not confident and decoded incorrectly</td>
<td>6.1%</td>
<td>6.1%</td>
</tr>
</tbody>
</table>
The second comparison, as shown in Table 2, is for a particular Primary Three (P3) class. Both tests consisted of 3 MCQs. Interestingly, the second test group revealed that more students had gotten their answers correct out of guesswork (9.1% in Test 1 versus 14.4% in Test 2), as reflected from the observation that they got the correct answers even when questions were decoded incorrectly. This also meant that the number of students with misconceptions on the topic was higher, resulting in the higher number of students decoding the question incorrectly.

Although we expected a reduction in the number of ‘lucky guesses’ for the Primary Three class, this did not happen, which could be attributed to the topic tested. The tests were based on different topics. Hence, there were differences in the topics and the skills tested.

### FINDINGS AND RECOMMENDATIONS

#### Benefits of the Tiered MCQ Test Format

With the tiered MCQ test format, teachers were better aware of their students’ learning after running the analysis of the answers. Students’ elaboration on their answers provided a clear understanding of their misconceptions. This critical information would help teachers to plan their lessons and pitch them to the right level. Teachers would then employ different approaches in teaching the same topic, based on the students’ profiles, to ensure their understanding. This could include templates for journal-writing and note-taking during revision or when revisiting the concepts.

Students who took the test in this format also reflected that writing their explanations for their answer choices made them examine their own answers first. This encouraged students to be critical of their responses. The requirement of writing down their explanations was also a way to get students to articulate their thinking. This was in line with the school initiative of ‘Making Thinking Visible’.

#### Limitations of Research

The research done was not without its limitations. Firstly, not many teachers were comfortable with the change in the existing test format. The new format required an increased amount of time for students to complete the test due to the additional two components. In addition, completing the analysis was a time-consuming process for teachers.

Moreover, as the topics of the tests used for comparison were different, further in-depth analyses of the results could not be done.

#### Scope for Future Development

The use of the tiered MCQ format has definitely added value to the teaching and learning process despite having several limitations. It is a useful tool to adopt in terms of developing both the students and the teacher. The primary concern would be to develop an easier way for teachers to categorise the question types so as to cut down processing time. This was one concern teachers raised with the use of this strategy. One possible solution is via ICT, through some means of coding to sort the student responses into various categories. However, this would require some coding knowledge and development time.

Another possibility to expand the use of such a format is the inclusion of past-year examination questions. Instead of using this evaluation method solely for determining the pacing of the lesson, such a tool can be used to help deepen students’ understanding and reasoning when it comes to attempting actual examination questions.


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Ahmad Tarmidzi has been teaching primary science for the past 6 years. He has participated in other action research projects in Assessment for Learning in primary science and shared at various national and international platforms. He was conferred the Associate of the Academy of Singapore Teachers (Primary School) in recognition of his significant contributions to the professional development of fellow MOE officers in 2015.
How Adapted ICBL Improves Scientific Explanation

ABSTRACT

This project addresses a specific concern in learning science at the primary school level. To enhance students’ learning experience and improve their scientific explanation, the Investigative Case-Based Learning (ICBL) approach was adapted for our purposes. It was anchored with ICT applications and formative assessment tools. To illustrate the impact of this approach, a modified summative assessment instrument known as the 2-tier multiple-choice question (MCQ) was used to gauge our students’ performance.

INTRODUCTION

This action research project aims to design Investigative Case-Based Learning (ICBL) lessons to help students develop conceptual thinking, hone experimental skills, and improve their scientific explanations. It was hypothesised that students would be able to achieve these objectives through the ICBL learning process. Two Primary 4 classes (Class A and Class B) with students at various levels of learning ability were selected for this study in 2015.

LITERATURE REVIEW

According to Wong, Lau, Lim, & Lim (2014), Investigative Case-Based Learning (ICBL) is an instructional approach in science that uses a case (a short story or scenario) to provide a rich context to stimulate scientific inquiry. This approach allows students to connect the scientific concepts they are learning about to authentic life experiences, which creates opportunities for them to execute learning tasks in problem posing, problem solving, and peer persuasion to develop conceptual thinking, experimental skills, and scientific explanations.

For the teachers, adopting the ICBL approach in science teaching and learning provides them with opportunities to make science content relevant and engaging (Stanley et al., 2012). The ICBL instructional approach is also understood to enhance students’ ability to develop their knowledge about science and make informed decisions on science issues (DeBoer, 2000; Holbrook & Rannikmae, 2009).

In addition, where assessment is concerned, Boo & Ang (2005) identified the mismatch of perspectives between the question-setter and the test-taker. In such situations, the students have no avenue to explain their reasons for choosing a particular option as the answer. Hence, besides building students’ scientific knowledge and literacy through ICBL, a 2-tier multiple-choice reasoning approach that allows students to justify their choice of answer was adopted to assess the students’ development of scientific explanation.
In 2014, the 2-tier multiple-choice question (MCQ) approach was adopted by our school for the Primary 4 students in Class A and Class B. The teaching objective was to strengthen the students’ ability to construct scientifically sound explanations. It was a successful action research project on summative assessment, and the Science Department decided to extend it to 2015.

For 2015, an explanation framework of ‘Claim, Evidence, Reasoning’ (CER) was added to the 2-tier MCQ approach. CER provided teachers and students with a common language and common expectations in the construction and critique of scientific explanations. Through the use of CER, students were able to make sense of data and scientific phenomena as well as hone their skills in constructing scientific explanations (Keeley et al., 2008).

Two new Classes A and B from the Primary 4 students in 2015 were selected for this study in Term 2. A 2-tier MCQ assessment was scheduled to be executed via their blogs in Phases A and B. The purpose of this online execution was to facilitate collaboration and discussion. However, due to technical glitches, students in Class B completed their assessment on paper.

In Phase A, students were required to select options and explain their choice without being taught CER. In Phase B, CER was introduced and students had the opportunity to adopt this approach as they answered the next set of questions on the same topic. Coincidently, the topic for the term, Heat, had just ended, and this exercise served as a summative assessment for these students. From their collective responses, their explanations in Phase B were more ‘scientifically’ sound than in Phase A (see Table 1).

To enhance students’ learning experience and improve their skills in constructing scientific explanation, an integrated learning vehicle utilising ICBL and anchored by ICT and the 2-tier MCQ reasoning pedagogy was conceived to deliver Light, the science topic in Term 3 (see Table 2).

### Table 1: Performance of Students in Phase A and Phase B

<table>
<thead>
<tr>
<th>Topic: Heat MCQ</th>
<th>Phase A</th>
<th>Phase B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Students</td>
<td>78</td>
<td>78</td>
</tr>
<tr>
<td>Number of acceptable explanations before CER taught</td>
<td>35</td>
<td>57</td>
</tr>
<tr>
<td>Number of acceptable explanations after CER taught</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of students not able to apply CER accurately</td>
<td>21</td>
<td></td>
</tr>
</tbody>
</table>

### Table 2: ICBL for Light

<table>
<thead>
<tr>
<th>ICBL (Topic: Light)</th>
<th>3 Phases of ICBL</th>
<th>ICBL Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesson Opening (1st and 2nd Lessons)</td>
<td>Problem Posing</td>
<td>Teacher&lt;br&gt;• Engages students with a case: ‘Starry Starry Night’.&lt;br&gt;• Guides students to use a KWL chart (formative assessment tool) to elicit their knowledge about light prior to experiencing a dark room effect. (KWL is an acronym for what students, in the course of a lesson, already Know, Want to know, and ultimately Learn.)&lt;br&gt;• Recognises the subtopics and concepts/ misconceptions of light.&lt;br&gt;• Generates the list of questions from the case based on the above.&lt;br&gt;• Decides on the question(s) to investigate.</td>
</tr>
<tr>
<td>Lesson Development (3rd to 5th Lessons)</td>
<td>Problem Solving</td>
<td>Students&lt;br&gt;• (in groups) Plan and design the experiment that relates to the selected question.&lt;br&gt;• Conduct the experiment.&lt;br&gt;• Collect data and formulate an explanation from conclusions using the scientific method.</td>
</tr>
<tr>
<td>Lesson Closure (6th to 8th Lessons)</td>
<td>Peer Persuasion</td>
<td>Students&lt;br&gt;• Communicate to justify their experiment design.&lt;br&gt;• Identify the flaws in their experiments.&lt;br&gt;• Take 2-tier MCQ assessment to check for concept understanding and scientific explanation.</td>
</tr>
</tbody>
</table>
For Term 4, the ICBL approach was modified to adopt the 5E instructional model due to a shorter time frame. This instructional model helps develop and improve teaching practice through discussion, observation, critique, and reflection. The facets of 5E are: Engage, Explore, Explain, Evaluate, and Extend. According to Wong, Lau, Lim, & Lim (2014), ICBL is flexible and allows changes to be made based on various considerations that include level of inquiry and instructional sequences. Hence, the topic, Water and its 3 States, was delivered using the 5E model in a lesson that contained facets similar to that found in the Light lesson (see Table 3).

Table 3: ICBL–5E for Water and its 3 States

<table>
<thead>
<tr>
<th>ICBL (Topic: Water)</th>
<th>3 Phases of modified ICBL – 5E</th>
<th>ICBL Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesson Opening (1st and 2nd Lessons)</td>
<td>Problem Identification</td>
<td>Teacher&lt;br&gt;• Engages students with a case: ‘Mr Survivor’.&lt;br&gt;• Recognises the issues from the case using KWL – get fresh water from sea water.&lt;br&gt;• Generates the list of possible methods.&lt;br&gt;• Decides on the question(s) to investigate.</td>
</tr>
<tr>
<td>Lesson Development (3rd to 5th Lessons)</td>
<td>Problem Solving</td>
<td>Students&lt;br&gt;• (in groups) Plan and design the model that relates to solving the issues. Due to the use of the burner, experiments are demonstrated by teachers.&lt;br&gt;• Make observations and formulate explanations from conclusions from these experiments. At the same time, they learn the scientific concepts that will help them design and build the model. They have to explore ideas to design and build the model.</td>
</tr>
<tr>
<td>Lesson Closure (6th to 8th Lessons)</td>
<td>Peer Persuasion</td>
<td>Students&lt;br&gt;• Communicate to justify and evaluate their model designs.&lt;br&gt;• Identify the flaws in their explanations based on the models they have built.&lt;br&gt;• Take 2-tier MCQ assessment to check for concept understanding and scientific explanation.</td>
</tr>
</tbody>
</table>

Table 4 below lists the scope of ICT applications and formative assessment tools (FAT) used in both lessons. The only formative assessment tool not listed is ‘Paint the Picture’ (Keeley et al., 2008), commonly known as drawing. This tool is used in the topic of Light, where students had to draw the layout of the experiment. At the same time, in Water and its 3 States, students had to draw and explain the model by which Mr Survivor would obtain fresh water from sea water.
Table 4: List of ICT & Formative Assessment Tools

<table>
<thead>
<tr>
<th>Technology</th>
<th>Tools</th>
<th>Functions/ Formative Assessment Tools (FAT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Management System (LMS)</td>
<td>AsknLearn</td>
<td>Integrated software functions that deliver learning resources to students seamlessly. Use of forums and blogs provided by the LMS allows students to share information and collaborate. Used in the topic of <em>Heat</em> in Phases A and B, as well as <em>Light</em> for the case analysis. Also used in experiment design and the 2-tier MCQ. FAT: KWL chart / CER</td>
</tr>
<tr>
<td>Communication and Collaboration</td>
<td>Linoit</td>
<td>Used as a collaborative workspace for groups of students to share information and reflections – a monological form of teaching. Used in <em>Light</em> and <em>Water</em> under ‘Mr Survivor’. Source: <a href="https://www.edidaktik.dk/en/linoit">https://www.edidaktik.dk/en/linoit</a> FAT: CER/ Explanation Analysis/ KWL</td>
</tr>
<tr>
<td></td>
<td>Socrative</td>
<td>A tool that is used for creating formative assessment and getting results in real time. Students’ results flash on the teacher’s screen as students respond to quizzes and questions. Hence, teachers can easily visualise what is happening and what students are doing at the moment. Educators can edit and design their own library of assessments and can also share this with their personal leaning network. Students’ understanding can be reviewed in different formats. Reports can be emailed, downloaded, or saved in Google Drive. Used in the topic of <em>Water</em> under ‘Mr Survivor’. Source: <a href="http://edtechreview.in/trends-insights/insights/1532-a-complete-guide-for-teachers-on-how-to-use-socrative">http://edtechreview.in/trends-insights/insights/1532-a-complete-guide-for-teachers-on-how-to-use-socrative</a> FAT: CER/ Explanation Analysis/ KWL</td>
</tr>
<tr>
<td>Word Processing</td>
<td>MS Office</td>
<td>Means of manipulating textual data given by the students. Tracking facilities allow building upon previous entries in the KWL chart, and the data can be updated based on students’ progress in learning. Used in the topic of <em>Light</em>. FAT: KWL</td>
</tr>
<tr>
<td>Web-based</td>
<td>Google Sites</td>
<td>Used as a collaborative workspace for groups of students to share information and reflections in real time. Videos, Google Docs, Google Slides, Linoit, and Socrative can be embedded as resources for collaboration and formative assessment. It functions like an interactive textbook that can be shared in real time. Used in the topic of <em>Water</em> under ‘Mr Survivor’. FAT: KWL/ CER</td>
</tr>
</tbody>
</table>

**IMPACT ON TEACHING AND LEARNING OF LIGHT**

Through this initiative, the engagement level of students in Science lessons was enhanced. The use of ICT to consolidate items taught was more efficient as students could refer to their completed work anytime. Students’ work on Linoit, Google Docs, and blogs and forums on AsknLearn allowed ease of viewing and distribution. The segment on experimental design opened the doors for these students to express their creativity and display application of scientific concepts. Most importantly, they had to explain scientific concepts, such as how shadows change size and the transparency of materials. The main issues that the students had were with crafting science experiments using the scientific method. This skill had to be learned and practised regularly. Refer to Table 5 for details on the FAT used at different stages of this lesson.
Table 5: Formative Assessment in Light

<table>
<thead>
<tr>
<th>Formative Assessment Tools</th>
<th>Reflections/Remarks</th>
</tr>
</thead>
</table>
| **Lesson Opening:** KWL Chart | • Promotes ownership of learning – the students are engaged with the topic as it is also an exercise for students to think about what they already know.  
• Provides a path for students to draw connections to their prior knowledge as they consider what they would like to find out and what they had already learned.  
• Through online platforms like Linoit, students can readily share their views and opinions.  
• From this exercise, students are led to design their own experiment using the scientific method that was taught as part of the lesson package. |
| **Lesson Development:** Paint the Picture | • From the case analysis using KWL, the students are taught to use the scientific method to plan and devise their own experiment to solve the identified problem. In the process of planning, they have to draw their experiment layout plan.  
• The learning artefact is a visual representation that reveals their thinking about the experiment they designed. |
| **Lesson Development:** Carry out Experiment | • Students carry out their designed experiments to find the answers to their problems. In the process, not all students are able to demonstrate the correct application of the scientific concepts covered in the lesson.  
• Post-experiment design sessions are carried out to address the mistakes made in the earlier lesson. The teacher has to conduct the experiments to demonstrate how they should be done correctly. Students are to complete an online reflection using forums in AsknLearn. |
| **Lesson Closure:** CER / Explanation Analysis with 2-Tier MCQ | • Helps students to write scientific explanations by making sense of data and scientific phenomena based on the analysis of the scenario.  
• Platform for students to practise the skill of constructing scientific explanations.  
• Provides a chance for students to work in groups to access their own and their peers’ explanations via the forum.  
• Teacher can provide feedback via the forum and guide the students in using CER.  
• Fulfills the summative assessment requirement to ensure that students are able to answer exam-oriented MCQ correctly and with confidence. |

**IMPACT ON TEACHING AND LEARNING OF WATER AND ITS 3 STATES**

Due to time constraints in Term 4, the ICBL approach was skewed towards a 5E platform without KWL. A case was presented to the students to solve. They needed to design a model, through drawing, that could help Mr Survivor to get fresh water from sea water as he was stranded on an island.

Teachers hosted Socrative, Linoit, and Google-based Office applications using Google Sites as a platform for students to record and share their knowledge. Videos and diagrams were located within the site so that students could access the information and validate their scientific concepts.

As students brainstormed possible solutions using the CER framework, they needed to validate their solutions with the correct scientific concepts using Linoit and Google Docs. In addition, students had created e-journals to record updates on their learning in real time during lessons. With this platform, they shared information as part of collaborative learning.

Due to safety considerations, experiments were carried out by teachers to introduce concepts like evaporation, condensation, and filtration. During these demonstrations, students had to make visual observations and determine the right experiment model to build. In the model design, students had to build the correct experiment model. In the process, their models had to depict both problem-solving considerations and correct scientific concepts. Both classes were able to determine the correct processes for obtaining fresh water from sea water i.e. through evaporation and condensation. There were some groups, however, which did not label the points at which these processes took place in the model.
The Google Sites below contain various facets of the concepts and activities for the students.

https://sites.google.com/site/waterclass45/home
https://sites.google.com/site/waterin46/

CONCLUSION

This project was conducted in collaboration with the Educational Technology Division (ETD), the National Institute of Education (NIE), and some schools in the ICT Good Practice Schools (IGPS) group, which aimed to develop ICT-infused lesson packages.

(Refer to this link: https://sites.google.com/a/moe.gov.sg/igps-afl-2015/home)

ICBL is a tried and tested approach, and teachers spent time learning and navigating the different functions of the intended ICT and formative assessment tools. ETD and NIE provided the overarching support and advisory roles for teachers that were greatly appreciated.

The project team concludes that teachers need to understand the constraints of this approach, and stay nimble to make adjustments to meet the demands of the school curriculum and students’ learning needs. While there are many potential benefits to implementing ICBL, teachers must be motivated to teach science, and be passionate about it.

The academic performance of the classes involved in the study has shown improvement. Using results from the SA1 Booklet B (40 marks) as a benchmark, most students managed to score better in SA2. From the combined performance of these 2 classes, 83% of 75 students had bettered their scores from the range of 1.0 to 11.5 (see Figures 1 and 2 for details). Nevertheless, the remaining 17% of the students did not manage to score higher marks. This has prompted a review of the ICBL approach to meet the needs of these students in the near future.

Figure 1: Booklet B Performance by Class A


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ABOUT THE CONTRIBUTOR

Gordon Chua Koon Leng has been teaching primary school science for 10 years. His current interests are in the use of information technology in teaching and the design of alternative modes of assessment using ICBL as the backdrop to teach science. As the school ICT mentor, Gordon has developed a strong interest in designing ICT lessons.
A Multi-Modal Approach in Teaching Chemical Bonding Using the Parallel Curriculum Model

ABSTRACT

Teachers from Cedar Girls’ Secondary School started to redesign their curriculum using the Parallel Curriculum (Tomlinson et al., 2002) as a model to guide students in mastering the key information, ideas, and fundamental skills of their disciplines in 2014. The first adapted Chemistry unit on Chemical Bonding was implemented in 2015 using a Lesson Study approach for Year 3 Integrated Programme students. Students were exposed to different pedagogical strategies during lesson instruction, including experimental inquiry, traditional tactile modelling, basic computer 3-D simulation, and inductive learning through collaboration. This multi-modal approach has been shown by some research to help students deepen their conceptual understanding. Student feedback showed an increased interest in the topic of Chemical Bonding as compared to students taught in the traditional way, as well as a deeper understanding of some fundamental concepts in Chemical Bonding. This article will discuss the key findings obtained through the conduct of the Lesson Study cycles.

INTRODUCTION

Chemical Bonding is an integral, yet abstract, unit in Chemistry. Two key problems often present themselves in the teaching of this topic. Students generally hold alternative conceptions and demonstrate a low level of engagement in the topic. Research has shown that the traditional, didactic lecture style of teaching does not help to address the issue of the alternative conceptions (Othman, Treagust, & Chandrasegaran, 2008; Özmen, 2004).

Effective mastery of the topic requires versatile translation between the macroscopic and microscopic modes of representing particles. The macroscopic mode is typically explored by experimental inquiry, but this is usually done at the lower secondary level where students are not expected to relate the physical properties of materials to their structure and bonding. The microscopic mode deals with concepts of structure and bonding on a scale which is invisible to the naked eye. Traditional pedagogical approaches tend to use 3-D molecular models to teach how the particles bond rather than how the process is related to their physical properties. The revised Chemical Bonding unit addresses this by inserting the necessary scaffolds, through peer discussion and effective questioning by the teacher, to ensure students are aware of the tripartite relationship between the bonding, structure, and physical properties of materials through the use of different models.
The unit plan contains activities that consider the constructivist approach to guided inquiry as the general teaching strategy. By facilitating multiple modes of content acquisition, the lessons provide students with opportunities to respond to a variety of stimuli (e.g. computer-simulated and traditional molecular models, videos, experiments) to acquire the core content. Students will define the relationship between chemical bonding, structure, and properties based on the case studies presented to them on worksheets. They will be engaged in collaborative knowledge sharing to encourage them to become more active learners.

Cedar Girls’ Secondary School has a core foundational approach to the Parallel Curriculum Model (PCM), where the knowledge and skills of the secondary school curriculum form the bedrock of the curriculum unit. Where appropriate, the Curriculum of Connections, Curriculum of Practice, and Curriculum of Identity are integrated in a seamless manner to ensure that students have a differentiated, yet holistic, learning experience (see Figure 1).

The Chemical Bonding unit plan was hence structured based on the above-mentioned approach. A summary of the flow of lessons and key strategies used is presented in Table 1.

**Table 1: Flow of Lessons for the Topic of Chemical Bonding**

<table>
<thead>
<tr>
<th>Lesson no.</th>
<th>Description of Lesson</th>
<th>Pedagogical Approach/Strategy</th>
<th>PCM Parallel Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 [Pre-unit Homework]</td>
<td>Introduction to Modelling in Chemistry: Online lesson using guided worksheet and website provided.</td>
<td>Flipped Classroom</td>
<td>Core, Connections</td>
</tr>
<tr>
<td>1</td>
<td>Introduction to Relationships: Experimental lab session to link Properties of Substances to Chemical Bonding &amp; Structure.</td>
<td>Teacher Demo using POE (Predict, Observe, Explain) Experiential Learning and Hands-on Activity</td>
<td>Core, Practice</td>
</tr>
<tr>
<td>2</td>
<td>Making links (in Relationships) between Structure and Bonding: Dry lab session using 3-D representations of the particulate structures to identify the type of structure each substance has.</td>
<td>ICT lesson using computer software Mercury 3.6</td>
<td>Core, Connections, Practice</td>
</tr>
</tbody>
</table>
Lesson no. | Description of Lesson | Pedagogical Approach/Strategy | PCM Parallel Used
---|---|---|---
*3 – 5 | Group discussion using the guided inquiry approach in Exercise 3 to help students: (a) make links (using concept of Relationships) between Structure, Bonding, and Properties; (b) deduce possible properties of a substance using these relationships. Physical 3-D models were also provided to help students visualise. | Co-operative Learning, 3-D Modelling & Visualisation | Core, Connections

| 6 – 9 | Follow-up lessons on other concepts involved in Chemical Bonding (e.g. Factors Affecting Chemical Bond Strength, Electronegativity) and practice questions. | Review and Reflect Consolidation of Concepts | Core, Connections, Identity

Note: * Lesson Study was conducted in Lesson 3

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**EVIDENCE OF IMPACT ON STUDENT LEARNING**

**Description**

Both qualitative and quantitative data were collected as evidence of impact on student learning.

Qualitative data was collected via the formative quizzing of students during lesson time, and through focus group discussions held with students outside the classroom. In addition, feedback from teachers during Professional Development sessions during curriculum hours was collated. Students generally agreed that visual aids and kinaesthetic activities were more engaging and helped them understand concepts in Chemical Bonding more clearly. Teachers also opined that students, through the collaborative group discussion, were able to delve deeper to develop a clearer understanding of some of the fundamental concepts in Chemical Bonding.

Qualitative and quantitative data were also collected through a survey that was administered at the end of Lesson 5 to assess if the restructured lessons were able to address the concern that the topic was often found to be uninteresting by students taught by the traditional, didactic method. Questions were also posed to get the students to report on whether the lessons helped them gain a better understanding of the concepts involved. The list of questions in the survey can be found in the Appendix.

**Survey Findings**

(i) 2015 Students (total no. = 146)

<table>
<thead>
<tr>
<th>Qn no.</th>
<th>Number (Agree/Strongly Agree)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>141</td>
<td>96.6</td>
</tr>
<tr>
<td>1b</td>
<td>135</td>
<td>92.5</td>
</tr>
<tr>
<td>2a</td>
<td>128</td>
<td>87.7</td>
</tr>
<tr>
<td>2b</td>
<td>113</td>
<td>77.4</td>
</tr>
<tr>
<td>3a</td>
<td>121</td>
<td>82.9</td>
</tr>
<tr>
<td>3b</td>
<td>122</td>
<td>83.6</td>
</tr>
</tbody>
</table>
(ii) 2016 Students (total no. = 87)

Table 3: Results of 2016 Batch

<table>
<thead>
<tr>
<th>Qn no.</th>
<th>Class 1</th>
<th>%</th>
<th>Class 2</th>
<th>%</th>
<th>Class 3</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>29</td>
<td>100.0</td>
<td>28</td>
<td>96.6</td>
<td>26</td>
<td>89.7</td>
</tr>
<tr>
<td>1b</td>
<td>25</td>
<td>86.2</td>
<td>25</td>
<td>86.2</td>
<td>25</td>
<td>86.2</td>
</tr>
<tr>
<td>2a</td>
<td>20</td>
<td>69.0</td>
<td>26</td>
<td>89.7</td>
<td>26</td>
<td>89.7</td>
</tr>
<tr>
<td>2b</td>
<td>21</td>
<td>72.4</td>
<td>26</td>
<td>89.7</td>
<td>29</td>
<td>100.0</td>
</tr>
<tr>
<td>3a</td>
<td>16</td>
<td>55.1</td>
<td>26</td>
<td>89.7</td>
<td>28</td>
<td>96.6</td>
</tr>
<tr>
<td>3b</td>
<td>16</td>
<td>55.1</td>
<td>28</td>
<td>96.6</td>
<td>27</td>
<td>93.1</td>
</tr>
<tr>
<td>Class Total</td>
<td>29</td>
<td>29</td>
<td>29</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CONCLUSION

The survey results for the 2015 batch, which included all 5 classes of Year 3 Integrated Programme students, show that a high percentage of students found the lessons interesting. The students also reported that the lessons generally helped to enhance their conceptual understanding of the concepts involved. However, close to 25% of the students felt that the computer simulation lessons were not that useful. There was also qualitative feedback from some students that the computer simulation was difficult to use.

In 2016, an upgraded version of the computer simulation programme was used, and there was more scaffolding provided to guide the students in the manipulation of the computer models. In this later study, the survey was administered to only 3 of the 5 Integrated Programme classes as one of the aims of the study was to determine if the lessons were found to be interesting and helpful to 2 different groups of students. The students in Classes 1 and 2 were of lower academic ability compared to students in Class 3. It was found that students in Class 2 generally gave favourable feedback, whereas those in Class 1 reported less favourable feedback, especially for Questions 3a and 3b. Those questions referred to the lessons which involved group discussions. Upon analysis of the class profile, it was concluded that group dynamics played a significant role in the difference in results as the students in Class 2 were generally more cooperative with each other as compared to those in Class 1, although both classes had students of similar academic ability. A comparison of the survey results of Classes 2 and 3, both of which were taught by the same teacher, seems to show that the lessons were equally appealing to both the weaker and stronger students.

It is therefore recommended that, before the teacher embarks on lessons which involve group work, the teacher should explain the rationale for doing group work to the students and monitor the group work very closely to address any issues that may arise due to group dynamics. This would greatly enhance the learning experience of the students and ensure that their learning needs are met.
REFERENCES


ABOUT THE CONTRIBUTORS

Koo Li Kheang is a Senior Teacher in Cedar Girls’ Secondary School, where she has been actively involved in developing Chemistry curriculum materials for the Victoria-Cedar Alliance Integrated Programme since the programme started in 2013. A winner of the 2016 Outstanding Science Teacher Award, Li Kheang is deeply passionate about developing an enriching curriculum for high-ability learners. She has shared her teaching experiences at local and international conferences.

Daniel Soh is the Subject Head of Chemistry in Cedar Girls’ Secondary School. In addition to developing curriculum resources for high-ability learners in Chemistry, Daniel’s current interests include the use of alternative assessment to promote social innovation in science education. He has shared his teaching experiences at local and international conferences.
Appendix

Survey on Chemical Bonding

In the series of 3 lessons to introduce the topic of Chemical Bonding, the lessons were:

Lesson 1: Lab demo and activity on Chemical Bonding and Properties
Lesson 2: Differentiation between giant and simple molecular structure using the software, Mercury 3.6
Lessons 3 – 5: Group discussion and collaborative learning using molecular models

Please rate the following statements according to the following legend:
Strongly Agree – 4, Agree – 3, Disagree – 2, Strongly Disagree – 1

If your choice is Disagree or Strongly Disagree, please give the reason why just below the statement.

<table>
<thead>
<tr>
<th>No.</th>
<th>Statement</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>The use of laboratory demonstrations and the hands-on activity in Lesson 1 made the lesson more engaging.</td>
<td></td>
</tr>
<tr>
<td>1b</td>
<td>The use of laboratory demonstrations and the hands-on activity in Lesson 1 helped me gain a better understanding of concepts involved.</td>
<td></td>
</tr>
<tr>
<td>2a</td>
<td>The use of visual aids like computer models in Lesson 2 and physical models in Lesson 3 made the lessons more engaging.</td>
<td></td>
</tr>
<tr>
<td>2b</td>
<td>The use of visual aids like computer models in Lesson 2 and physical models in Lesson 3 helped me gain a better understanding of concepts involved.</td>
<td></td>
</tr>
<tr>
<td>3a</td>
<td>The use of group discussions during Lesson 3 made the lesson more engaging.</td>
<td></td>
</tr>
<tr>
<td>3b</td>
<td>The use of group discussions during Lesson 3 helped me gain a better understanding of concepts involved.</td>
<td></td>
</tr>
</tbody>
</table>
A quote from an article by Steven Wolk, *The Positive Classroom* (2008), particularly resonates with me: “Joyful learning can flourish in school, if you give joy a chance.” Wolk does not use the word ‘joy’ as a synonym for fun. He advocates that teachers help students find pleasure in learning by nurturing their curiosity, inspiring them to ask questions, and transforming their notion of assessment as an enemy into a more positive learning experience. As teachers, we should dispel the idea of being in control all the time. Instead we need to “take risks, experiment, play with the art of pedagogy” (ibid., p. 10), and as we tinker with our teaching, we will find that teaching is a joyful, albeit energy-sapping, experience.

In a recent study, Professor John Wang, who leads the National Institute of Education’s (NIE) Motivation in Educational Research Lab, found that “Teachers draw energy from their students when they are teaching. If they can focus on creating a conducive learning environment, both teachers and students will experience the joy of teaching and learning.” *(The Straits Times, April 19, 2017).*

At the upper secondary levels, Chemistry is one subject that many students seem to have difficulties with in terms of both learning and doing well in examinations (Risch, 2014). Students find it quite daunting and often fail to see its relevance to their lives, so they resort to rote learning without much understanding. When they constantly struggle with the subject, they soon find their interest waning, and they eventually give up on the subject altogether.

This was indeed what we noticed about student learning in our school at Secondary Four and Secondary Five when we had our Chemistry Professional Development (PD) discussions at the start of the year. We observed that, while students had been exposed to a few Chemistry topics at the lower secondary levels, an oft-heard comment by upper secondary Chemistry teachers was that many students were not very interested nor actively engaged when these topics were re-visited at Secondary Three. The teachers also found that, when students were asked to select subjects that would qualify them for study at post-secondary institutions, quite a number did not choose Chemistry. When probed, they commented that they found Chemistry uninteresting, abstract, and difficult to understand, and they could not see how it was relevant to their lives. Hence, they were not confident about achieving good academic grades in the subject, and a few students even requested to be allowed not to offer the subject at the national examinations.

Greenview Secondary School believes that students learn more effectively through pedagogical approaches and strategies that make learning relevant and engaging. This article explains how Differentiated Instruction (DI), Socratic Questioning for Critical Thinking (SQCT) and Short Learning-Assessment Cycles (SLAC) are incorporated into Chemistry lessons to engage students in interesting and meaningful ways that motivate them to learn.
Another observation that we made was associated with high-performing Chemistry students. While these were self-driven students, they were assessment-oriented and motivated to learn only those facts and skills related to tests and examinations. Many were diligent but passive learners who preferred that their teachers provided answers to scientific challenges posed, and relied on them to do so, instead of thinking critically and creatively on their own to solve the problems.

We realised that we had to do something, and quickly, too, if we wanted our students to be enthusiastic about learning Chemistry, be engaged in learning, think of solutions by themselves, and have an intrinsic interest in Chemistry, and all these not just for the sake of passing examinations. To do this, we had to ensure that our students enjoyed their learning of Chemistry, and also help them see the relevance of Chemistry in the world that they live in. We felt that it was critical that we did this at the Secondary Three level when students first encountered Chemistry as a ‘pure’ science subject. A decision was thus made to revamp the way some topics in Chemistry were taught at Secondary Three – we had to take a more student-centric approach to lesson delivery so that students’ interest in the subject would be triggered and sustained. During our PD sharing sessions, we also discussed ways of letting students taste success early so as to boost their self-confidence and motivate them to want to learn more and further. This meant that we also had to change some of the ways by which we assessed our students’ learning.

According to Carol Ann Tomlinson, Differentiated Instruction (DI) is the process of “ensuring that what a student learns, how he or she learns it, and how the student demonstrates what he or she has learned is a match for that student’s readiness level, interests, and preferred mode of learning” (cited by Ellis, Gable, Greg, & Rock, 2008, p. 32). Applied to our situation, this meant that we had to plan and customise our instruction and assessment in relation to our students’ needs, abilities, and experiences.

When we reflected on our lesson delivery of the Secondary Three Chemistry curriculum, we realised that we had mostly been teaching topics such as Experimental Design, Separation Techniques, and Kinetic Particle Theory in a teacher-centred manner. This was based on our assumption that students only needed to revise these topics since they had already been exposed to them at the lower secondary levels. Small wonder, then, that our students did not display enthusiasm in the revision tasks set for them.

We began our foray into DI by first studying our student profile more closely in terms of interest and experience. While we already knew that many of our students were kinaesthetic learners, we were pleasantly surprised that they were fans of intriguing television police dramas and crime movies. This inspired us to apply DI to two seemingly boring topics – Experimental Design and Separation Techniques – and we recrafted our lessons to model a crime scene investigation, thus appealing to our students’ interest and preferred learning mode. We also applied the DI strategy to the lessons for our Normal (Academic) (NA) students by differentiating them further according to student readiness.

Setting the Scene (Designing the Lesson Unit)

To start with, teachers revised relevant skills with students, such as making observations, measuring lengths of footprints, calculating volumes of solutions, measuring the time taken for reactions to take place, and separating mixtures using experimental techniques e.g. filtration and chromatography.

A crime scenario (Figure 1) was then created about a break-in at our Science laboratory, and we even set up a crime scene, props and all. The ‘Crime Scene Report’ comprised teacher-designed worksheets which described the profiles of the different suspects involved (Figure 2). To further create an element of fun in the lessons, these suspects were given the names of the teachers who taught the classes. As forensic scientists, students had to use the clues provided to take measurements, conduct experiments, and make observations and comparisons in order to solve the case.
Crime Scene Report:

At approximately 6:30 am on Friday morning, the lab technician noticed that the door of the Chemistry lab was open. He was shocked to find the following:

- The glass cover of the chemical cabinet had been smashed.
- A bottle of Chemical X was left open on the table.
- Liquid spills with traces of brown powdery substance were on the table.
- A note with scribbles was found on the floor.
- Faint footprint marks on the floor.
- Candy wrappers found in the dustbin.

The police were summoned as Chemical X is flammable and can pose a danger to the school. When they arrived, the forensic team began to gather evidence from the crime scene.

They managed to recover some of these evidences:

- Fingerprint marks from the table.
- Measurements of the footprints.
- The brown powder suspension was collected for examination.
- The note was carefully placed in a plastic bag and taken to the forensic chemist for identification.
## Suspect Description Report

<table>
<thead>
<tr>
<th>Name / Description</th>
<th>General Characteristics</th>
<th>Fingerprint sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr Lim Male</td>
<td>Mr Lim is the school attendant. He often has an angry look. He eats candies to curb his anger. He claimed that he was on duty at the school gate when the crime occurred. His uniform was wet and muddy due to the heavy rain.</td>
<td>![Fingerprint Image]</td>
</tr>
<tr>
<td>Ms Yip Female</td>
<td>Ms Yip is a clumsy person who always breaks and spills chemicals in class. She eats candies to keep herself awake. She carries some scented powder in her pouch. She claimed that she reached school at 7:30 am due to the heavy rain.</td>
<td>![Fingerprint Image]</td>
</tr>
<tr>
<td>Kia Yi Female</td>
<td>Kia Yi is a vain student. She carries her compact foundation with her in school. She likes to offer candies to her friends. She fought with her clique recently and is being ignored by them. Her uniform was soiled and had a weird smell in class that day.</td>
<td>![Fingerprint Image]</td>
</tr>
<tr>
<td>Imma Female</td>
<td>Imma does not hang out with other students. She enjoys doing Science experiments and once almost started a fire in the lab. She is addicted to sweets and loves to bake cakes. She brought a pack of brown sugar for her FCE lesson on that day.</td>
<td>![Fingerprint Image]</td>
</tr>
<tr>
<td>Ronald Male</td>
<td>Ronald is a mischievous boy who loves Science and sports. His mum reports that her missing candies are often found in his bedroom. Ronald claimed that he was playing soccer before school. His uniform was sweaty and soiled with mud.</td>
<td>![Fingerprint Image]</td>
</tr>
</tbody>
</table>

You are the forensic scientist who is responsible for examining the crime evidence by applying various techniques. You have to record the findings and give a simple analysis of the results to the police.

The pieces of evidence are found on the next page. In CSI, speed and good observational skills are crucial too!

All the best! May you crack the case soon!

---

Figure 2: List of Suspects
Different Strokes for Different Folks
(Differentiating the Tasks)

Stations were set up in the laboratory, and each required students to demonstrate their understanding and execution of different skills and experimental techniques. Students had to work in pairs and move from station to station in an orderly manner so as to complete their tasks and gather ‘evidence’ to solve their case. To render the case more realistic and for better student management, some teachers set a duration for each task, so students had to move on when their time at a station was up.

Tasks at each station were differentiated according to student readiness. For Chemistry (Pure) students, adjustments were made to the crime scenario to allow for more challenging tasks to be set e.g. students were required to calculate Rf values and conduct chemical analysis on the solid to identify it. Express course Chemistry students were given autonomy to read the instructions on the worksheets and conduct experiments with minimal help. For NA students, support was provided at each station e.g. printouts of step-by-step instructions on how to take readings. Teachers and laboratory assistants also moved around to offer help when necessary.

(2) A PINCH OF SQCT IN ELECTROLYSIS

In this fast-paced 21st century, we need to equip our students with crucial life skills that will enable them to survive a VUCA (Volatile, Uncertain, Complex, Ambiguous) world frequently disrupted by global events. Thinking critically is an important life skill that will help students to function more effectively in their daily lives, both now and in the future. As critical thinking is driven by questions, not answers, we need to arouse in our students a curiosity that leads to their wanting to ask questions, as well as develop in them the skill of asking appropriate questions that would deepen their thinking. Through such Socratic questioning, our students can learn to better frame their thinking and develop into more self-directed learners.

From our PD discussions, we realised that, while we had incorporated questions into our lessons, it was generally the teachers who asked the questions, thus resulting in our allocating less time for students to be curious and pursue other questions. Moreover, the purpose of the teachers’ questions was mainly to check on students’ understanding, and not so much to make students think deeply or inquisitively about scientific theories, hypotheses, concepts, or processes.

We decided that we should engage our students in Socratic Questioning for Critical Thinking in our lessons and, hence, adopted Richard Paul’s Six Types of Socratic Questions (cited in http://www.umich.edu/~elements/probsolv/strategy/cthinking.htm).

Using Socratic Questioning (Designing the Lesson Unit)

For this topic, Electrolysis, students were first provided with basic knowledge of electrolysis. With higher-progress classes, students were asked to read their textbooks before the start of the unit.

Students were then tasked to conduct petri-dish electrolysis in pairs while referring to a teacher-crafted worksheet on which questions were intentionally inserted at every step of the activity. These were Richard Paul’s Six Types of Socratic Questions, which we used to probe students’ thinking and challenge them to think more deeply about the performance of certain procedures in their assigned tasks (Figure 3).
Figure 3: Using Richard Paul’s Socratic Questions

Answering Questions with Questions (Facilitating Student Thinking)

During the lessons, students were put into situations in which they experienced phenomena, analysed results, investigated ideas and questions more deeply, questioned assumptions, and made predictions on occurrences and outcomes when the parameters of the experiment were changed. Teachers facilitated students’ learning through answering their questions with further questions. Students were expected to present their results and justify them, with guidance from the questions on the worksheet.

According to Lev Vygotsky, the role of education is to provide children with experiences which are in their Zone of Proximal Development (ZPD), thereby encouraging and advancing their individual learning. Vygotsky defines ZPD as the distance between the level of actual development as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers (cited in http://www.innovativelearning.com/educational_psychology/development/zone-of-proximal-development.html).

We were reminded of the ZPD by our Principal who had observed that test results showed that our students were coping less well with long learning-assessment cycles. This was attributed to the fact that, as the content and skills that students were taught in particular topics or units extended beyond their ZPD, it was difficult for them to learn well and perform effectively on individual assessments. Moreover, as students are more motivated to learn when they experience success, especially those who are less academically ready, it was important that we used short learning-assessment cycles (SLAC) to help them learn in manageable chunks and to ensure they were assessed using bite-sized assessments. Such learning experiences incorporated teachers’ use of concept and mind maps, learning logs, targeted written assignments, exit tickets, Kahoot quizzes, non-graded quizzes, pre-tests, and mini-tests, just to name a few. The purpose of these bite-sized assessments, given at regular intervals, was to constantly diagnose student needs and clarify learning targets with them, as well as to adjust teacher instruction so as to guide students in what they could do to close their learning gaps and increase their learning.
CONCLUSION

We were encouraged and motivated by the much higher engagement levels of students when DI, SQCT, and SLAC were implemented. Although planning and designing the activities was time-consuming, teachers felt that the time and efforts spent were worthwhile. Through DI and SQCT, more students seemed to be taking ownership of their learning as they were beginning to ask questions of their teachers and peers, and even students who were usually unruly in class were observed to exhibit more on-task behaviour. Once students had to think of solutions on their own, they became more curious and engaged in the inquiry processes of critical thinking, which deepened their understanding of scientific theories and concepts and helped them to see the relevance of Chemistry in their lives. What was inspiring was also the observation that, the more students were confident about their learning, the greater the increase in their achievement and motivation.

Moving forward, teachers would need to help students extend their ZPD progressively so that they would be able to attempt longer and more demanding summative assessments as successfully as they currently do in bite-sized formative assessments.

REFERENCES


ABOUT THE CONTRIBUTOR

Rachel Koh-Wong has more than 20 years of experience teaching Chemistry in secondary schools. She was Subject Head (Science) before assuming her position as Senior Teacher and Instructional Mentor in her current school. She derives great joy in working with teachers, especially beginning teachers, in pedagogies and strategies to better engage students in their learning. Her current interests are Differentiated Instruction and Assessment for Learning.
Developing a Common Feedback Language Using a Problem-Solving Checklist in Physics

Changkat Changi Secondary School (CCSS) has embarked on using formative assessment in our teaching and learning. In formative assessment, feedback is instrumental in moving the student forward in the learning process. However, the challenge is for teachers to give feedback efficiently and effectively such that students are able to understand it and use it to make improvement. For feedback to be effective, it must be succinct and easily understood by students.

The students are first taught a 5-Step Problem-Solving (PS) Strategy. Thereafter, students solve problems and teachers mark their answers using the PS checklist, and give feedback specific to the student’s proficiency at each step. Notation will be used to reduce writing, thus making it easier for teachers to give feedback and also for students to read and decipher it.

The PS strategy serves as a tool for students in problem solving. In addition, as a common understanding and language between teachers and students is built, efficient and effective giving and receiving of feedback between them is facilitated. Although some students still find the PS strategy time consuming, with more practice, we hope students will be able to see the benefits of using it.

ABSTRACT

Feedback is important in formative assessment in order to help students move forward in their learning, as highlighted by Wiliam (2016).

The challenge for teachers is to search for a way of writing feedback that is practical and effective in helping the student. Teachers faced with a stack of papers to mark may resort to the use of circles, jagged lines, or question marks as part of feedback notation, and which often provide no information on how a student can improve or move forward. For feedback to be effective, it must be easy to write and sustainable for teachers, as well as easy for students to read and decipher. Thus, having a common feedback language may help teachers’ efficiency and economy in writing feedback that is succinct yet comprehensive.
In writing feedback, it is helpful to keep in mind the 5 characteristics of effective feedback as delineated by Chappius (Chappius, 2015, p. 95):

- Directs attention to the intended learning, pointing out strengths and offering specific information to guide improvement;
- Occurs during learning, while there is time to act on it;
- Addresses partial understanding;
- Does not do the thinking for the student; and
- Limits corrective information to the amount of advice the student can act on.

Another important characteristic of effective feedback is that it must be student-friendly, in the sense that students are able to use the comments to move forward. Hattie & Timperley (2007, pp. 81 – 112) highlighted that “corrective feedback can be ignored by students if it is poorly presented or if the student’s knowledge is insufficient to accommodate additional feedback information.”

The framework or structure of a common feedback language adopted by our school is built upon a problem-solving checklist introduced to the students in a Teacher Leaders Programme 1 (TLPI) research project, “Using Cognitive Strategy Checklist to enhance Students’ Problem-Solving Skills”, under the supervision of Dr Chua Bee Ling. It was later used as a frame of reference for giving written feedback to students. In the quest to make written feedback effective for students and efficient for teachers, the idea of using the checklist as a framework for a common feedback language between students and teachers was developed. This 5-Step Problem-Solving (PS) Strategy and accompanying checklist were presented at the East Zone Centre Of Excellence Teaching & Learning Professional Sharing 2017 and invaluable feedback on the idea was received from participating colleagues.

The framework of a common feedback language adopted by our school is built upon a problem-solving checklist introduced to the students in a Teacher Leaders Programme 1 (TLPI) research project, “Using Cognitive Strategy Checklist to enhance Students’ Problem-Solving Skills”, under the supervision of Dr Chua Bee Ling. It was later used as a frame of reference for giving written feedback to students. In the quest to make written feedback effective for students and efficient for teachers, the idea of using the checklist as a framework for a common feedback language between students and teachers was developed. This 5-Step Problem-Solving (PS) Strategy and accompanying checklist were presented at the East Zone Centre Of Excellence Teaching & Learning Professional Sharing 2017 and invaluable feedback on the idea was received from participating colleagues.

**Table 1: Differences between Polya’s 4-Step and the PS Strategy’s 5-Step Checklists**

<table>
<thead>
<tr>
<th>Polya’s ‘How to Solve It’ (4 Steps)</th>
<th>Problem-Solving Strategy (5 Steps)</th>
<th>Main Actions for Quantitative OR Qualitative Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Understand the Problem</td>
<td>1 What is the question asking?</td>
<td>Write down the physical quantity to be determined in terms of symbols. OR Identify whether the question is asking you to state, explain, or explain in terms of specific physics quantities, etc.</td>
</tr>
<tr>
<td>2 Obtain important data from the question.</td>
<td>Write down important data in equation form using symbols. You may need to make deductions to obtain numerical values. OR Identify key subject-specific terms that have to be included in the answer.</td>
<td></td>
</tr>
</tbody>
</table>

1 Note that Steps 1 & 2 have been interchanged from the earlier version of the checklist as used in the TLPI research project as well as EZ COE T&L Sharing.
<table>
<thead>
<tr>
<th>Polyà’s ‘How to Solve It’ (4 Steps)</th>
<th>Problem-Solving Strategy (5 Steps)</th>
<th>Main Actions for Quantitative OR Qualitative Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Make a Plan</td>
<td>3 Identify relevant concepts, principles, or equations.</td>
<td>Write down equations that relate the physical quantities (PQ) to be solved with the PQs of data given. OR Write down key terms, ideas, concepts, laws, etc. to be included in the answer.</td>
</tr>
<tr>
<td>3 Do the Plan</td>
<td>4 Substitute values OR sequence explanation.</td>
<td>Substitute the relevant data in the correct SI units into the equation. OR Sequence the answer using key terms so that it is systematic and logical to provide a coherent explanation.</td>
</tr>
<tr>
<td>4 Look Back</td>
<td>5 Check.</td>
<td>Check if values, workings, calculations, significant figures, and units are correct. OR Check that the answer is logical and coherent.</td>
</tr>
</tbody>
</table>

**Exemplar 1** below illustrates how the 5-step PS checklist was applied in solving problems.

**Exemplar 1**
Figure below shows a short ruler being used to measure the thickness of a stack of metal slabs.

![Image of metal slabs being measured](image_url)

Calculate the thickness of one of the slabs of metal.
The problem-solving steps are illustrated in the ‘Workings’ column.

<table>
<thead>
<tr>
<th>Polya’s Model</th>
<th>PS Checklist</th>
<th>Actions</th>
<th>Workings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understand the Problem</td>
<td>1</td>
<td>Determine what the question is asking.</td>
<td>Thickness of 1 metal slab = ( t = ? )</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Identify important information data.</td>
<td>Thickness of metal slabs = 10.6 - 0.6 = 10.0 cm Number of metal slabs = 9</td>
</tr>
<tr>
<td>Make a Plan</td>
<td>3</td>
<td>Identify the topic, theory, law, or formula that is relevant.</td>
<td>Thickness of 9 metal slabs = 9 ( t ) Thickness of 9 metal slabs = 10.0 cm</td>
</tr>
<tr>
<td>Do the Plan</td>
<td>4</td>
<td>Substitute the data with correct SI units into the equation.</td>
<td>( 9 \ t = 10.0 ) cm ( t = 10.0/9 = 1.1111 ) cm</td>
</tr>
<tr>
<td>Look Back</td>
<td>5</td>
<td>Check for correct value/ no. of significant figures/ correct units.</td>
<td>( t = 1.1 ) cm</td>
</tr>
</tbody>
</table>

Exemplar 1 is particularly helpful in illustrating the problem-solving steps as it does not involve any physics concepts except the number of decimal places or significant figures in the final answer.

Students’ responses to using the checklist were mixed. Some viewed it as laborious and an additional cognitive load, while others found the checklist helpful in guiding their thinking processes and enabling them to work out the steps systematically. Steps 1 and 2 are not necessary in short questions as information can be gleaned from such questions easily, but they are helpful in guiding students when solving more data-based questions or complicated problems with lots of information to be gleaned. Writing out Steps 1 and 2 allows information to be conveniently viewed at one glance.

**NOTATION IN WRITTEN FEEDBACK USING THE PS CHECKLIST**

Initially, to highlight the importance of feedback to students, the written feedback comments were preceded by the letter ‘F’, to remind them that it is a feedback comment. A number was added to the letter ‘F’ to indicate the specific step it referred to e.g. ‘F1’ refers to feedback on Step 1. Table 2 below shows samples of the feedback notation that was developed. The ‘reduced version’ attempts to make written comments shorter by using symbols and equations.

<table>
<thead>
<tr>
<th>PS Checklist</th>
<th>Notation</th>
<th>Feedback Comments</th>
<th>Reduced Version Comments</th>
<th>Explanation of Reduced Version Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>F1.1</td>
<td>Rewrite the question in the form of an equation.</td>
<td>F1.1 PQ = ?</td>
<td>Need to write out physical quantities (PQ) in words &amp; symbols.</td>
</tr>
<tr>
<td></td>
<td>F1.2</td>
<td>State whether there are any specific units for the answer.</td>
<td>F1.2 PQ = ___N/cm(^2).</td>
<td>Need to include the units to be expressed in the final answer.</td>
</tr>
</tbody>
</table>

Table 2: Feedback Notation in the 5-Step PS Strategy
<table>
<thead>
<tr>
<th>PS Checklist</th>
<th>Notation</th>
<th>Feedback Comments</th>
<th>Reduced Version Comments</th>
<th>Explanation of Reduced Version Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 2</strong></td>
<td>F2.1</td>
<td>Identify the physical quantities for each data item.</td>
<td>F2.1 SI units m = 165 g ( \Rightarrow \ldots \ldots \ldots )</td>
<td>Best to write out in symbols &amp; units.</td>
</tr>
<tr>
<td></td>
<td>F2.2</td>
<td>List all given data.</td>
<td>F2.2 “constant velocity” ( a = 2 )</td>
<td>Need to translate word descriptions into numerical values.</td>
</tr>
<tr>
<td></td>
<td>F2.3</td>
<td>Draw a diagram to represent the data given.</td>
<td>F2.3</td>
<td>Need to draw diagrams for Dynamics &amp; Circuits.</td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td>F3.1</td>
<td>Identify the (likely) topic, laws, or equations that are relevant.</td>
<td>F3.1 Dynamics? OR Mass, Weight &amp; Density?</td>
<td>This is a hook to help students recall relevant information, especially when more topics are covered.</td>
</tr>
<tr>
<td></td>
<td>F3.2</td>
<td>Write out equation in symbols. Check whether equation is correct by looking at problem to solve and data given.</td>
<td>F3.2 ( m = F/a ) OR ( m = W/g )</td>
<td>Write possible equations and then eliminate based on data given &amp; question to be solved.</td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td>F4.1</td>
<td>Substitute the data in the required or correct units.</td>
<td>F4.1 Substitution/ Units</td>
<td>Need to know SI units of all PQs to avoid mistakes. Need to know cm(^2) to m(^2). Convert to SI units when necessary.</td>
</tr>
<tr>
<td></td>
<td>F4.2</td>
<td>Check whether the correct data is used in the substitution.</td>
<td>F4.2 Frictional force or resultant force?</td>
<td>Especially when data given has 2 PQs with the same units.</td>
</tr>
<tr>
<td><strong>Step 5</strong></td>
<td>F5.1</td>
<td>Check and correct your answer to 2 or 3 significant figures.</td>
<td>F5.1 ( sf )?</td>
<td>All final answers must be in decimals. No fractions.</td>
</tr>
<tr>
<td></td>
<td>F5.2</td>
<td>Check whether your answer is in the correct units.</td>
<td>F5.2 units?</td>
<td>Units for answers are given in Sect B but not for Sect C.</td>
</tr>
<tr>
<td></td>
<td>F5.3</td>
<td>Check whether the question is answered, and the equation, substitution, &amp; calculations are correct.</td>
<td></td>
<td>Checking should have been done at each step &amp; this is checking for the overall process, starting with interpretation of the question.</td>
</tr>
</tbody>
</table>
A subsequent improvement to the ‘F’ notation was to separate the feedback into two categories: ‘S’ and ‘P’ notations. ‘S’ refers to the students’ application of steps on the PS checklist and ‘P’ refers to physics concepts in each of the steps. The use of the ‘S’ and ‘P’ notations directed students’ attention to the specific step in their problem solving and also the physics concepts to focus on. Table 3 below illustrates how the ‘S’ and ‘P’ notations were used in writing feedback.

Table 3: ‘S’ and ‘P’ Notations in the 5-Step PS Strategy

<table>
<thead>
<tr>
<th>PS Checklist</th>
<th>Applying Steps in Checklist</th>
<th>Applying Physics Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Notation</td>
<td>Feedback Comments</td>
</tr>
<tr>
<td><strong>Step 1</strong></td>
<td>Identity what the question is asking.</td>
<td>S1.1 PQs are not listed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td>Extract data from question.</td>
<td>S2.1 PQs are not written correctly.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td>Identify topic or equation that relates the data given to the problem to be solved.</td>
<td>S3.1 No equations written.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS Checklist</td>
<td>Applying Steps in Checklist</td>
<td>Applying Physics Concepts</td>
</tr>
<tr>
<td>-------------</td>
<td>----------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td></td>
<td>Notation</td>
<td>Feedback Comments</td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substitute</td>
<td>S4.1</td>
<td>Substitute</td>
</tr>
<tr>
<td>data into</td>
<td></td>
<td>without units.</td>
</tr>
<tr>
<td>equation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>S4.2</td>
<td>Not using</td>
</tr>
<tr>
<td></td>
<td></td>
<td>the correct</td>
</tr>
<tr>
<td></td>
<td></td>
<td>symbols e.g. f, F,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R.</td>
</tr>
<tr>
<td><strong>Step 5</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check</td>
<td>S5.1</td>
<td>Need to check</td>
</tr>
<tr>
<td>working &amp;</td>
<td></td>
<td>if answer is in</td>
</tr>
<tr>
<td>final</td>
<td></td>
<td>2 or 3 significant</td>
</tr>
<tr>
<td>answer units</td>
<td></td>
<td>figures.</td>
</tr>
<tr>
<td>&amp; significant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>figures (sf)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>S5.2</td>
<td>Check whether</td>
</tr>
<tr>
<td></td>
<td></td>
<td>your answer is in</td>
</tr>
<tr>
<td></td>
<td></td>
<td>the correct</td>
</tr>
<tr>
<td></td>
<td></td>
<td>units.</td>
</tr>
<tr>
<td></td>
<td>S5.3</td>
<td>Check whether</td>
</tr>
<tr>
<td></td>
<td></td>
<td>calculations are</td>
</tr>
<tr>
<td></td>
<td></td>
<td>correct.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CONCLUSION**

The use of feedback notation forces students to work to decipher the feedback and do some thinking on their own in order to use the feedback effectively. William highlighted that one way of way of ensuring students actively use feedback is “to make responding to the feedback a task in itself. In other words, make feedback into detective work.” (William, 2016, pp. 10 – 15)

In addition, the use of notation helps teachers in the writing of feedback as it reduces the number of words, yet is effective in communicating meaning through common understanding of the feedback language.

The notation also allows students to track their strengths and weaknesses in each of the steps in problem solving with greater clarity with respect to their remedial needs. Moreover, it facilitates students’ giving of peer feedback.
as there is a common understanding of the steps on the checklist. As students attain greater mastery of the topic, written feedback can be reduced to writing the notation symbols with just a word or two. The students will then think about and interpret what is lacking, and hopefully self-correct.

A written feedback comments bank for the different topics can be prepared and given to students so that they can give peer feedback more effectively.

It is our hope that the problem-solving checklist provides a robust base for a common language of written feedback between teachers and students. The written feedback comments can be customised according to the mastery level of topics as well as the proficiency of the students.

We will be exploring how the problem-solving checklist can be used in answering qualitative questions as well, so that students can have a single problem-solving checklist for a number of subjects.

REFERENCES


Teacher Leaders Programme 1 for Senior Teachers conducted jointly by National Institute Education and Academy Singapore of Teachers. (July 2016). Research Project, Class 1A, Using Cognitive Strategy to Enhance Students’ Problem-Solving Skills. Singapore. (Team members: Alvin Bek Aik Chiang, Hong Kam Kheun, Basil Dominic Varella, Chen Li Yan, Nor Rasidah Binte Mohamed Saleh & Naufal Bin AB Hadi.)


ABOUT THE CONTRIBUTORS

Hong Kam Kheun is a Physics Senior Teacher at Changkat Changi Secondary School. He started teaching in a Junior College (JC) and resigned after 10 years of teaching. When he re-joined the education service, he applied to teach in a secondary school. The stark difference between the learning profiles of secondary school students and JC students prompted him to experiment with different pedagogies in the teaching of physics concepts and principles. Currently, he is using an interest-based pedagogical approach that uses variety in lesson format and delivery to pique students’ curiosity and make them look forward to classroom lessons. He has shared his teaching ideas at various workshops and will be sharing the interest-based pedagogy at the International Science Education Conference (ISEC) 2018.

Lee Chin Teck is currently Lead Teacher/ Physics in Changkat Changi Secondary School. He has been in MOE for 15 years and his pedagogical area of interest is in John Hattie’s Visible Learning and Socratic Questioning. He has presented papers at Teaching and Learning conferences both locally and in Austria, Brisbane, and Washington D.C.
Introduction of Guided Argumentative Activities for Year 1 Biology

ABSTRACT

In June 2015, Year 1 Biology teachers attended a course on “Critical Thinking in Science Lessons”. Biology teachers were introduced to the idea of argumentation as one of the teaching strategies to improve students’ critical thinking and articulation of thought processes as scientists. The 21st century competencies outlined by the Ministry of Education (MOE) include sound reasoning and decision-making. In view of that, an innovative move was made to use learning cards in teaching the topic of cells. Students would use these cards to debate the question: “What is Euglena?”, based on given evidence for a cell or organism. This activity also enabled students to appreciate that, in real life, taxonomic scientists may not have clear-cut answers, but will decide the type of the organism based on observable characteristics. This move takes on a constructivist approach as students are allowed to build on their knowledge, instead of having the teacher dictate the entire lesson with didactic content. In addition, group work is involved in the rearrangement of cards.

INTRODUCTION

In 2016, we enacted a minor change. One class of Year 1 students used a graphic organiser to build on their argument for “What is Euglena?”. This involved the understanding of terminology such as ‘problem statements’, ‘claims’, and ‘alternative claims’, as the students had to write guided arguments using these terms on the graphic organiser. We wanted to increase the opportunities for students’ self-directed learning, reflective thinking, and metacognition in order to deepen their thinking processes for sound argumentation in science-related topics. We hoped that, in time to come, they would be able to manage complex and ambiguous situations at the upper secondary level and beyond, such as bioethical issues.

USE OF THE BSCS 5E MODEL IN THE TEACHING OF BIOLOGY IN DHS IP

The lesson comprised learning activities through guided arguments on the topic of Euglena, and it was based on the Biological Sciences Curriculum Study (BSCS) 5E Learning Framework by Bybee (2009). Refer to Figure 1 and Table 1.
Table 1: How the BSCS 5E Model is Integrated into Year 1 Biology Lessons

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engage</td>
<td>Students are to indicate, by colouring, the categories that the various characteristics of Euglena could belong to i.e. whether it is a plant, an animal, either a plant or an animal, or neither a plant nor an animal.</td>
</tr>
<tr>
<td>Explore</td>
<td>Students work in groups of 4 to classify cards listing evidence of the characteristics of Euglena.</td>
</tr>
<tr>
<td>Explain</td>
<td>Students record their arguments on a guided graphic organiser, then discuss what they think Euglena is.</td>
</tr>
<tr>
<td>Elaborate</td>
<td>Students share their thoughts with the class or write them down on their own worksheets. They have a chance to consolidate their thoughts and complete a guided write-up on what Euglena is.</td>
</tr>
<tr>
<td>Evaluate</td>
<td>Students use the online survey and share the challenges they faced on this lesson, and how the given evidence was helpful, or not, to them. Possible extension in future: Students can imagine they are scientists who have discovered Euglena and have to share the factors which will help them decide how to categorise Euglena. Alternatively, students can research if similar situations were faced by scientists in history or in recent years in the field of taxonomy.</td>
</tr>
</tbody>
</table>

21st Century Skills

Figure 2 captures some key skills which students would have gained during this lesson through the guided argument activities. Students were given the chance to share their views and make decisions based on evidence given to them, following which, they had to conclude what Euglena is, even though it would have been unknown to most of them.
PLANNING: USE OF LESSON STUDY AS OUR FACILITATION TOOL

Our Professional Learning Team, consisting of lower secondary teachers, took 2 years to refine our lesson study. Table 2 in the Appendix shows the timeline and the various stages in the 2 years of the lesson study.

Research Questions in our Lesson Study:

Q1: How can we bridge the learning gaps in students’ understanding of cells and cell structure?
Q2: How do argumentative activities such as the rearrangement of cards help students to articulate their thoughts on “What is Euglena?”?
Q3: What can teachers learn from:
   • the questions generated by students after lessons;
   • students’ suggestions on how their learning can be improved; and
   • students’ strengths exhibited during the lesson?

Provision for 21st Century Skills

Critical thinking

Students were required to think through the main question: “What is Euglena?”, and they were expected to discuss their thoughts with their groups through guided activities. Thereafter, they had to write a short paragraph on “What is Euglena?” based on evidence, claims, and alternative claims. Students were tasked to ask questions and record questions raised during the rearrangement of the learning cards as a means to develop critical thinking.

Collaboration

Students were in groups of four to complete their activities and for discussion. The activity deepened teachers’ understanding of students’ learning gaps. It was clear that students were not familiar with the phrases used in the lesson. Students were also not used to learning in the format of an argumentative debate. Students could have been too comfortable with conventional lecture-style teaching and with learning science through drilling for national exams. Learning through debates and seeking clarification through friendly arguments are crucial skills which can be introduced in Year 2 Science lessons. Opportunities can be provided during class time to discuss questions. However, this may be difficult to implement, as teachers may not be able to plan lessons effectively, with the limited curriculum time, to allow for in-depth discussion and independent learning.

EXECUTION OF LEARNING PACKAGE AND FEEDBACK ANALYSIS

The lesson was carried out according to the flowchart in Figure 3. Students were asked to colour the characteristics of Euglena according to category: whether it is a plant, an animal, either a plant or animal, or neither a plant nor animal. This was followed by group work and discussion on the rearrangement of the characteristics of the organism on a chart, and students shared their thoughts with their peers. As closure, the teacher used the ICT tool Kahoot to summarise the students’ conclusions on Euglena. Students were then asked to do a short individual write-up on Euglena. Samples of the students’ work are shown in Pictures 1, 2, and 3 in the Appendix.
Survey 1 was done after the lesson. Based on Graph 1, most students accepted that Euglena was neither a plant nor an animal, and 4% perceived it as a plant. The rest of the students had difficulty in accepting that some organisms could be neither a plant nor an animal. Anecdotally, a few students wondered whether Euglena was a bacterium as it was a single-cell organism.

Graph 1: Students’ Conclusions on “What is Euglena?”

From Graph 2, students indicated that they enjoyed the “Group discussion with organiser”, followed by the “Rearrangement of cards as a group”, then “Using the organiser as an individual”, which was when they wrote their mini essays.

Graph 2: Students’ Indication of the Most Helpful Activity
The online responses to the following 3 questions on Survey 1 were collated and analysed with respect to students’ misconceptions (see Graph 3).

1a) Select the evidence below that is the most debatable. Please select by placing a tick in one of the boxes below.

1b) Select the evidence below that is the most confusing to your final decision on “What is Euglena?”. Please select by placing a tick in one of the boxes below.

1c) Select the evidence below that would help you generate many questions on “What is Euglena?”.

Based on Graph 3, teachers teaching the topic of cells can highlight the possible misconception that a cell which has a cell wall or chloroplast must be a plant cell. The idea of cells changing their shapes was also quite unfamiliar to students as they might not have seen such cells or heard of any cells other than the amoeba. These are fixed ideas which might have been entrenched in students in primary school, especially if they had studied science by memorising information instead of understanding and applying concepts.

The following 2 open-ended questions were also useful in identifying areas for teachers to focus on.

1d) Write your question(s) that was/were generated during the activity on “What is Euglena?”. 

Graph 3: Students’ Answers to Qs 1a), b), and c) in Survey 1
Based on Graph 4, it is observed that the students like to generate questions on the cell wall and ask about the composition of the cell wall, as both bacteria and plant cells have cell walls. The next most common question is on the idea of cells changing shape and how cells obtain food. Teachers will have to spend time to clarify these concepts on cell wall composition and how cells obtain food.

5c) Could I identify one strength shown during the lesson today? How was this strength used during the lesson?

With reference to Graph 5, most students wrote about the organiser and teamwork. It is affirming to know that students can remember their strengths from their Character and Citizenship Education (CCE) lessons. Identification of strengths can be carried out more frequently in daily lessons with various subject teachers to affirm students and build their self-confidence and self-efficacy in their academic subjects.
Students perceived that they have low declarative knowledge, a term which was used in the Metacognitive Awareness Inventory (Schraw & Dennison, 1994). Declarative knowledge is the factual knowledge that the learner needs before being able to process or use critical thinking related to the topic. This group of students perceived themselves as being unable to organise information and remember information, but very sure of what the teacher expects them to learn.

Another evaluation survey (Survey 2) related to metacognition was done in the later part of the year.

From Graph 6, another area to note is the depth of conditional knowledge for this group of students. Conditional knowledge is about when and why to use learning procedures. Only a few students perceived that they find themselves not “using different learning strategies depending on various situations”, and the same students are also not confident of knowing when each strategy use will be most effective.

**Graph 6: Conditional Knowledge of one Year 1 Class (2016)**
The data collected from Survey 2, with reference to Graphs 6 and 7, can help educators to redesign lessons for the Year 2 Science curriculum. Teachers can make a more conscious effort to improve students’ conditional knowledge. Learning strategies can be incorporated into students’ learning. Helping students to apply their knowledge to solve real-life problems is essential, as the students may only prioritise memorising information in order to pass their examinations. Students do have self-awareness as some of them do realise that they are not good at organising their information, and that they might need more structured time to reflect on and organise their thoughts during lessons.

Figure 4 sums up the study on Euglena with one class of Year 1 students. Students had an opportunity to reflect on their strengths after the lesson with Survey 1, and they gave feedback on how they would improve their learning to overcome challenges. Decision-making was also infused as students had to work in groups to discuss and come to a final decision on what Euglena is. Through the stages of guided argument and the use of an organiser, students improved in their critical thinking skills as they had to make their claims and alternative claims.

Survey 2 further explored students’ awareness of their metacognition. This helped educators to consider improving future lessons by including specific metacognition domains such as conditional knowledge. This can be followed up in future studies.
Implementation in Future
Lessons on Euglena including activities to develop students’ critical thinking are an attempt to improve students’ learning and their ability to articulate their views using guided arguments. Students generally enjoyed this lesson, with 89.7% of them indicating that they liked the lessons. Lessons in Year 2 can be infused with discussions on bioethics, and the use of argumentative organisers for debates can be used in other subjects. Through Survey 2, teachers obtained insights into students’ metacognition and were reminded to model their own use of metacognition by thinking out loud.

REFERENCES


ABOUT THE CONTRIBUTORS

Christine Tan C. K. has been teaching lower secondary Science (Biology) and involved in Values in Action for about 15 years. Her current interests are service learning and environmental education. She conducted sharing sessions on service learning in research in educational conferences in Singapore and Hong Kong in 2014. She is currently Subject Head/ Values in Action.

Geraldine R. Joseph is an experienced teacher of 4 years, passionate about Biology and student leadership.

Ian Zhao Bolun is a teacher who has kept himself updated with ICT trends in education and has been passionately teaching Biology for 3 years.

Adrian Ong W. X. was recently appointed Subject Head/ Lower Secondary Science. He has been teaching for about 5 years and is also active in student leadership in school.

Jeffrey Ng J. L. is currently Subject Head in Biology, with teaching experience of about 10 years. His interests are in Science and Volleyball.

June Loh C. Y. has been teaching Biology with dedication for about 15 years. She is currently the Year Head in Years 1 and 2, and cares for students’ well-being in school.

Appendix

Table 2: Timeline of Professional Learning Team Lesson Study in 2016 and 2017

<table>
<thead>
<tr>
<th>Stages of Lesson Study</th>
<th>2015 (Term 3)</th>
<th>2016 (Term 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research question</td>
<td>Can Year 1 students identify what Euglena is via a student-centered activity using cards?</td>
<td>How do Year 1 students identify what Euglena is with guided arguments in Science?</td>
</tr>
<tr>
<td>Goal setting</td>
<td>Team met up for Time-tabled Time (TTT) and shared the potential of using cards as a student-centred activity for lesson study.</td>
<td>Team met up for TTT and shared the potential of using cards as a student-centred activity and a graphic organiser for lesson study.</td>
</tr>
<tr>
<td>Lesson selection and planning</td>
<td>Subject teacher (A) prepared the lesson plan and shared her lesson focus during TTT.</td>
<td>Subject teacher (B) prepared the lesson plan and shared her lesson focus during TTT.</td>
</tr>
<tr>
<td>Teaching lesson with peer observation</td>
<td>School-based Gifted Education (SBGE) Class 1J’15 was observed. 5 teachers were involved. Students are higher-ability students.</td>
<td>Class 1F’16 was observed. 5 teachers were involved. Students are generally weaker in their academic subjects.</td>
</tr>
<tr>
<td>Debriefing the lesson</td>
<td>TTT was used for consolidating learning points. Teachers reported on some of their findings.</td>
<td>TTT was used for consolidating learning points. Data was collected from students based on survey.</td>
</tr>
<tr>
<td>Consolidation of learning</td>
<td>Refinement of lesson was discussed for 2016. More data should be collected from students. A graphic organiser can be used to summarise the lesson.</td>
<td>Refinement of lesson was discussed for 2017. Argumentation skills should continue to be developed in Year 2 or Year 3, using issues related to bioethics, such as the sale of organs for transplant, or the genetic selection of babies.</td>
</tr>
</tbody>
</table>

Lesson Study Stages adapted from http://www.lifescied.org/content/3/1/1/F1.expansion
Picture 1: Sample of Students’ Individual Work

<table>
<thead>
<tr>
<th>Individual task:</th>
<th>Euglena is a plant, animal, both or neither based on the given characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shade the appropriate color for each characteristic using the key above.</td>
<td></td>
</tr>
<tr>
<td>Euglena does not have a cell wall?</td>
<td></td>
</tr>
<tr>
<td>Euglena has a nucleus.</td>
<td></td>
</tr>
<tr>
<td>Euglena can obtain food from its surrounding.</td>
<td></td>
</tr>
<tr>
<td>Euglena is normally green.</td>
<td></td>
</tr>
<tr>
<td>Euglena has chloroplasts for photosynthesis.</td>
<td></td>
</tr>
<tr>
<td>Euglena has a vacuole.</td>
<td></td>
</tr>
<tr>
<td>Euglena contains cytoplasm.</td>
<td></td>
</tr>
<tr>
<td>Euglena reproduces.</td>
<td></td>
</tr>
<tr>
<td>Euglena lives in ponds and puddles.</td>
<td></td>
</tr>
<tr>
<td>Euglena’s nucleus contains DNA and controls the cell.</td>
<td></td>
</tr>
<tr>
<td>Euglena has a flagellum to swim through water.</td>
<td></td>
</tr>
<tr>
<td>Euglena is temperature sensitive.</td>
<td></td>
</tr>
<tr>
<td>Euglena can change its shape.</td>
<td></td>
</tr>
</tbody>
</table>

Picture 2: Sample of Students’ Group Work on Rearrangement of Cards

Picture 3: Sample of Students’ Group Opinions on Euglena
The Use of Peer Assessment and Modified ‘Post–Tea House Teaching’ Approach in Teaching the Revised Syllabus in H2 Chemistry

ABSTRACT

The revised H2 Chemistry syllabus not only requires students to be familiar with a wide repertoire of practical skills, but also has greater emphasis on the application of content and skills with a higher weighting given to data-based questions.

The purpose of this study was to evaluate the effectiveness of peer assessment and the modified ‘Post–Tea House Teaching’ (PTHT) approach in enhancing the teaching and learning of the revised H2 Chemistry syllabus. In this project, we found that peer assessment (with checklist) of students’ practical skills helped them to master practical skills and build their confidence in carrying out laboratory work. The use of the modified PTHT approach, which leverages on the components: read–read (读读), practise–practise (练练), discuss–discuss (议议), and talk–talk (讲讲), increased student-centredness in lesson delivery and enhanced students’ competence in tackling data-based questions.

INTRODUCTION

Practical Skills (Using Peer Assessment)

In the revised H2 Chemistry syllabus (implemented in 2016), Science Practical Assessment is no longer school-based. All students have to sit for a practical paper on a stipulated date, before the theory papers for A-Level examinations begin. As such, students need to be familiar with a wide repertoire of practical skills in all topics in their syllabus. To prepare students adequately for the practical assessment, we decided to study the effectiveness of the peer assessment approach to assessing their mastery of practical skills. The use of peer assessment has the following benefits, and students will receive the benefits whether they believe it is a valuable activity or not (Kaufman & Schunn, 2011):

- Enhances students’ active engagement;
- Encourages students to take ownership of their learning;
- Is a form of Assessment for Learning as students receive an increased amount of feedback on their work; and
- Helps students to understand and achieve ‘good work’.

Data–based Questions (Using the Modified ‘Post–Tea House Teaching’ Approach)

In the revised H2 Chemistry syllabus (implemented in 2016), there is also a higher weighting of data-based questions in Paper 2 with the increased emphasis on application of content and skills as part of our desired outcomes of education.

It is thus imperative that the curriculum is designed to effectively help the students acquire skills and knowledge to build their 21st century competencies, as well as to meet the demands of data-based questions at the A-Level examinations. To improve on our lesson planning and delivery, we explored the use of the modified ‘Post–Tea House Teaching’ (PTHT) approach, which has the following benefits (Charlene, 2013):

- Increased student-centredness – the focus is totally on prompting students to think and exposing what the students do not understand; and
- Alignment with Lev Vygotsky’s concept of Zone of Proximal Development (ZPD) – design of lessons is based on the best developmental period, and teaching is based on the highest ZPD.
Practical Skills (Using Peer Assessment)
The practical skills study was conducted for all 13 Chemistry classes of the Year 5 cohort.

In implementing peer assessment, a Titration Skills Checklist (see Figure 1) was given to every student during the last Volumetric Analysis practical lesson. Students were paired up and instructed to take turns to assess each other’s skills as they did their practical work, using the observation checklist. When both students had completed the assessment, each gave feedback to the other. These checklists were then submitted to the teacher who conducted a mass debrief towards the end of the practical lesson, highlighting the common mistakes made by the students. At the end of the practical lesson, the teacher would then choose 4 to 5 students from each class, generally those with poorer practical skills, to be observed further in a subsequent practical test. A total of 52 students were identified for this.

Data-based Questions (Using the Modified PTHT Approach)
The Year 5 cohort was split into two groups, namely the experimental (Classes A, B, and C) and control (the remaining classes) groups. The experimental group was taught using the modified PTHT approach as described below.

1. (read-read 读读, practise-practise 练练) Assign homework (see Figure 2) for students to read, with questions to answer on their own. Students to submit homework to teacher so that he or she can identify disparate thinking and inadequacies from students’ work.

2. (discuss-discuss 议议) Small-group discussions in class: students discuss answers with their classmates and explain their reasoning.

3. (talk-talk 讲讲) Teacher talk: the teacher then discusses selected questions with the class, and teaches intensively to clarify students’ doubts. (The lesson caters to the needs of the students based on their work; the teacher will not go through what the students can learn on their own.)
Practical Skills (Using Peer Assessment)

To evaluate the effectiveness of peer assessment in helping students acquire practical skills, the checklists of the 52 students with poorer practical skills obtained during the practical lesson and during the subsequent practical test were compared (see Figure 3).

The following observations were made based on the comparison:

- 46 out of the 52 students with poorer practical skills made improvement (fewer crosses (x) observed on the checklist) during the practical test. The remaining 6 students had the same number of crosses (x) on their practical test. None of the 52 students had more crosses (x) on their practical test. The most improved student had 8 fewer crosses (x) on his practical test.

- All students also showed competence in performing skills under ‘Preparing Standard Solutions’. These skills were not previously peer evaluated during the practical lesson. However, the students were verbally briefed on these skills during the practical lesson.

The peer evaluation checklist benefited the students. They were more actively engaged during practical lessons and showed greater awareness of the skills required and greater confidence in performing to achieve the standard of work expected of them.

Additionally, the peer assessment approach was well received by the students (number of respondents = 164) based on the following survey results (see Table 1).
Table 1: Survey Questions and Results for Peer Assessment using Checklists

<table>
<thead>
<tr>
<th>Survey Questions for Peer Assessment using Checklists</th>
<th>Strongly Agree &amp; Agree (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The peer evaluation &amp; feedback helped me to improve on my titration skills &amp; techniques.</td>
<td>79.3</td>
</tr>
<tr>
<td>The practical skills checklist raises my awareness of titration skills.</td>
<td>95.7</td>
</tr>
<tr>
<td>With the practical skills checklist, I am more confident of my titration results.</td>
<td>89.7</td>
</tr>
<tr>
<td>With the practical skills checklist, I am more competent in performing titration.</td>
<td>93.3</td>
</tr>
</tbody>
</table>

Data-based Questions (Using the Modified PTHT Approach)

To evaluate the effectiveness of the modified PTHT approach in helping students tackle data-based questions, test scores were collected after every data-based assessment and compared between the control and experimental groups (see Table 2). Three classes (X, Y, and Z) were identified from the control group for comparison with the experimental group (Classes A, B, and C) based on their Secondary 4 mean percentage for Chemistry.

Table 2: Comparison of Test Scores between Control and Experimental Classes

<table>
<thead>
<tr>
<th>Sec 4 Chemistry Mean %</th>
<th>Test [9 marks]</th>
<th>Mid-Year Exam [10 marks]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental Class A</td>
<td>75.37</td>
<td>4.42</td>
</tr>
<tr>
<td>Control Class X</td>
<td>77.39</td>
<td>4.52</td>
</tr>
<tr>
<td>% w.r.t control</td>
<td>-2.61</td>
<td>-2.23</td>
</tr>
<tr>
<td>Experimental Class B</td>
<td>79.75</td>
<td>4.70</td>
</tr>
<tr>
<td>Control Class Y</td>
<td>78.04</td>
<td>4.21</td>
</tr>
<tr>
<td>% w.r.t control</td>
<td>+2.19</td>
<td>+11.68</td>
</tr>
<tr>
<td>Experimental Class C</td>
<td>74.00</td>
<td>4.41</td>
</tr>
<tr>
<td>Control Class Z</td>
<td>73.44</td>
<td>3.72</td>
</tr>
<tr>
<td>% w.r.t control</td>
<td>+0.76</td>
<td>+18.60</td>
</tr>
</tbody>
</table>

The following observations were made based on the comparison of scores:

• Classes A and X: Class A has a lower Sec 4 mean % for Chemistry, but the students eventually obtained higher scores for the Mid-Year Examination.
• Classes B and Y: Class B, which has a slightly higher Sec 4 mean % for Chemistry, showed significant gains in performance for both assessments.
• Classes C and Z: Classes C and Z have comparable Sec 4 mean % for Chemistry. While Class C obtained much better scores for the test, Class Z eventually outperformed Class C in the Mid-Year Examination.

The analysis of the data generally showed the positive impact of the modified PTHT approach in helping students to deal with data-based questions. One of the factors which could have contributed to the inconsistency in the performance of Class C as compared to Class Z in the Mid-Year Examination could be the limited number of lessons conducted using the modified PTHT approach due to time constraints.
The lessons conducted using the modified PTHT approach were also generally well received by the students (number of respondents = 56) based on the following survey results (see Table 3).

Table 3: Survey Questions and Results for Lessons Conducted Using Modified PTHT Approach

<table>
<thead>
<tr>
<th>Survey Questions for Lessons Conducted Using the Modified PTHT Approach</th>
<th>Strongly Agree &amp; Agree (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I find the lessons useful in helping me to understand the various ways of representing data (e.g. tables, text graphs, diagrams).</td>
<td>74.6</td>
</tr>
<tr>
<td>I find the lessons useful in helping me to identify and apply relevant data given in the question.</td>
<td>78.7</td>
</tr>
<tr>
<td>The group discussion during the lessons allowed me to reason aloud to my peers or hear from my peers regarding how data could be analysed.</td>
<td>66.6</td>
</tr>
<tr>
<td>With the exposure to the data-based homework, I have become more confident in handling data-based questions.</td>
<td>70.7</td>
</tr>
<tr>
<td>I would like to have more data-based homework to prepare me for the examination.</td>
<td>96.0</td>
</tr>
</tbody>
</table>

Based on our preliminary findings, the use of peer assessment with checklists and the modified PTHT approach are effective in achieving our desired learning outcomes. Further work to expand the scope and depth of our research is needed to sustain the impact on the development of practical skills and competence in solving data-based questions. For example, the checklists could be used to assess practical skills for other physical chemistry topics and qualitative analysis, and more regular lessons using the modified PTHT approach could be conducted to better evaluate the effectiveness of the pedagogy.

CONCLUSION

REFERENCES


Goh Wei Bin has been teaching GCE A–Level Chemistry for 6 years. He has a keen interest in using teaching strategies and formative assessments to augment students’ conceptual understanding in chemistry.

Lee Li Juan is a high school teacher at Dunman High School, Singapore. She has been teaching GCE A–Level Chemistry for 8 years. She is an advocate of formative assessment and the use of technology to enhance students’ learning and engagement.

Neo Sock Khim has been teaching GCE A–Level Chemistry for more than 10 years. She has been actively involved in exploring different teaching pedagogies to suit the learning needs of her students. These include leveraging on the affordances of ICT, differentiated learning, and assessment methods to deepen students’ understanding in chemistry.
An open classroom lesson observation was conducted with the weakest Biology class. The students were both weak in conceptual understanding as well as poorly motivated. The lesson started with a recapitulation of key terms and definitions, followed by task allocation for student presentations, and then a teacher debrief after the students’ presentations. Finally, the students worked on a tutorial structured question that required the application of content.

**Recapitulation**

A recap of the key terms and definitions was conducted prior to the student model presentations. The first part of the structured question on operons, which required students to label the various parts of an operon, was projected on the white board (see Figure 1) and students were asked to provide answers for the labels. Questioning was then used to elicit definitions of the key terms and concepts from the students.
Q1. The figure shows a diagram of an **inducible**, the *lac* operon.

Identify components a - i.

**Figure 1: Extract from Tutorial Question 1 used for Recapitulation**

**Task Allocation**

Students were then allocated randomly into groups of 5 and given a presentation kit. Each kit contained a set of magnetic models (see **Figure 2**), a list of keywords (see **Figure 3**) that they were instructed to use during the presentation, and a unique set of conditions to explain (see **Figure 4**). They were given 5 minutes to prepare and write out their scripts before making their presentations to the class.

- Operator
- Promoter
- Structural genes
- Repressor
- Lactose
- Glucose
- cAMP
- allolactose
- Co-Repressor
- Active conformation
- Inactive conformation
- cAMP Receptor Protein (CRP)
- CRP binding site

**Figure 2: Example of Magnetic Models *lac* Operon Presentation Kit**

**Figure 3: Key Words Provided in Presentation Kit**
Group 1: *Trp* operon  
Condition 1: Tryptophan absent  
Condition 2: Tryptophan present

Group 2: *Lac* operon  
Conditions: Lactose absent, glucose present

Group 3: *Lac* operon  
Conditions: Lactose absent, glucose absent

Group 4: *Lac* operon  
Conditions: Lactose present, glucose present

Group 5: *Lac* operon  
Conditions: Lactose present, glucose absent

**Figure 4: Conditions for Groups to Explain**

**Student Presentations and Teacher Summary**

Each group was given 3 minutes to present its work to the class. The audience was tasked to pose questions to clarify any aspects and to identify areas of misconception during the presentations. At the end of the presentations, the teacher facilitated a short discourse to address misconceptions and reinforced the key conceptual learning to help students draw links and see the big picture.

Prizes were given for ‘most engaging’ and ‘most informative’ presentations, which were voted for by the teacher observers present.

**Tutorial Question**

A tutorial question on the *lac* operon was then discussed in class as a model for the students to follow so they could apply the concepts learnt and stage their answers with the appropriate answering technique (see **Figure 5**). Students were instructed to attempt this question at home before coming for the lesson. The students were asked to present their original answers before the teacher used questioning pedagogy to guide students to improve their answers.

Q2. Briefly explain the expression of the *lac* operon in the presence of lactose and glucose. [4]

**Figure 5: Extract from Tutorial Question 2**

**Observer Feedback**

There were seven teachers from various schools within the East Zone observing the lesson. The feedback for this lesson was positive, particularly in the following domains:

a) Preparation / Lesson Lead-in
   - Asking leading questions in recap
   - Projecting a worksheet on the whiteboard and using it to recap and elaborate on concepts

b) Teaching Tools
   - Using magnetic manipulative models to represent abstract concepts
   - Providing presentation kits including conceptual keywords to scaffold learning

c) Student Engagement
   - Use of student presentations to increase engagement levels

**Strengths**

The use of models helped to improve students’ understanding of abstract concepts. During the group preparation time, students were engaged in manipulating the model to explain the concepts to each other. A lot of thinking out loud took place as they corrected each other and discussed what occurs.

Presentation kits with key words provided were helpful in scaffolding the students to explain concepts with the right scientific language and detail. Students were seen referring to the key words often when attempting to explain concepts to each other.

Students were able to point out that their original answers were not very complete. They were better able to stage their answers and include more relevant details and/ or key words after the student presentations during the tutorial segment. They seemed to better grasp the concepts, but still needed questioning by the teacher to give a more complete answer.
Areas for Improvement
The quality of student presentations was not as good as expected, even with the amount of scaffolding provided with the key words given. Not all groups drafted a proper script using all the key words and, therefore, gave incomplete descriptions. Some did not organise their presentations very coherently. Most of the groups were given feedback and recommendations to make their presentations more engaging.

While the instructions given to the groups were adequate and scaffolding was sufficient, we felt that student motivation for the task could have been better. The students were generally more reserved and needed a lot of encouragement to create more effective presentations. A possible means of rallying the students to enhance their presentations to garner votes would be to involve them in voting for the ‘most engaging’ and ‘most informative’ presentations, instead of having only the teacher observers vote.

CONCLUSION
Using concrete models to visualise abstract concepts is an effective pedagogical tool in the teaching of biology. Students need to be provided with sufficient hands-on time to make the lesson effective. In order to augment learning, it is essential for the teacher to facilitate the connection of the various concepts within the larger topic, consolidate the key learning points of the activity, and encourage students to ask questions.

REFERENCES


ABOUT THE CONTRIBUTORS
Jillian Cheong and Loh Kok Sheng have been teaching A-Level Biology for 8 and 7 years respectively.

Their interests lie in developing pedagogical tools and lesson packages for the teaching of Biology.

Jillian and Kok Sheng were involved in unit projects to develop several lesson packages and teaching materials, including an original organelle board called “Cell Concept”, which won Dunman High’s in-house Most Innovative Teaching Award (MITA) 2010. This board game was then shared at the Biology IPSG 2011 and Excel Fest 2012 and published and put into circulation. Their latest contribution is a modified board game – Pandemic Infectious Disease Edition – which was developed and submitted for MITA 2017 and shared during the Biology IPSG 2018. They also conducted Biology IPSG sharing in 2012 for a lesson package on alternative assessment featuring student model presentations on DNA replication, Transcription, and Translation, and participated in MITA 2014, submitting a SPA planning skills package.
The teaching of history has often been reduced to a teacher-centric and didactic model. Such an approach is preferred by many teachers as it is arguably the most efficient approach to employ in covering curriculum, especially when curriculum time is in short supply. However, this model would deprive students of authenticity in the learning of historical events and, more importantly, of the opportunity to empathise with historical figures and the decisions they made. As such, students are often only able to articulate factual information without depth in their explanations for and understanding of historical events.

The authors recognise the merits of this conventional pedagogy, but strive to supplement it with more engaging approaches in the teaching of selected historical events. Studies have shown that game-based learning is more effective for learning than traditional classroom instruction (Boller & Kapp, 2017). Through simulation, it is hoped that students would experience the complexity behind the making of foreign policy and the uncertainty of international relations (McCall, 2013, p. 23). At the end of the simulation, students should be able to explain the rationale of historical actors, thus arriving at a deeper understanding of the historical event rather than simply accepting the ‘outcomes’ of history.

The authors decided to use simulation as a tool for the teaching of the July Crisis (World War I) and the Cuban Missile Crisis (Cold War). These events, which saw countries in crisis management mode with varying degrees of success, lend themselves to various interpretations of the causes and consequences of conflict in modern world history. Simulations offer an interactive experience that provides learners with a realistic, controlled-risk environment to practise specific behaviours and experience the effects of their decisions (Boller & Kapp, 2017). While the use of simulation in the classroom is not entirely new, the authors have adapted role-play simulation by increasing the degree of student interaction so as to heighten the sense of ‘realism’ and facilitate the learning process. The nature of these events also revolved around the pivotal decisions made by the leaders of various countries that could have led to, or did lead to, catastrophic consequences. The authors saw the potential in the use of simulation as a means of replicating the complexity of this decision-making process in the history classroom (Counsell, Burn, & Chapman, 2016, p. 160).
The authors first identified a gap in both the students’ learning of historical events and the pedagogy most often used by history teachers. It was found that the didactic approach in the teaching of history has limited the effectiveness of students’ learning, especially in terms of their enduring understanding. This often translated to students learning historical events in a piecemeal fashion without fully comprehending the nature of the relationship between the cause and the effect of historical developments, thus often resulting in them treating history as a literary exercise (McCall, 2013, p. 13).

According to Seixas & Morton (2013), the idea of agency, or the power to act, is essential in understanding cause and consequence in history. Historians have wrestled with the level of influence causal factors have on one another and, therefore, on the course of history. In the context of crisis simulations, it is important for students to understand that events did not develop in a linear manner. Rather, prevailing attitudes in society then and human agency came together to play an important role in the crises. The historical concept of cause and consequence is something that the authors wanted to exemplify through the simulation. A key objective of the simulation was to develop accomplished students of historical thinking who are able to analyse the set of causes and describe how they influence one another (Seixas & Morton, 2013).

Moreover, students’ retention of historical knowledge is evanescent, with most students being unable to recall beyond what is tested in examinations. Rote learning is often the preferred way for students to remember the past, as many teachers would attest to. The authors wanted a more engaging way of learning history that would enable students to retain not just facts but also the context behind historical developments. This would then allow for greater transferability of knowledge, especially in the application of understanding to present-day context.

For effective learning to take place, the core dynamics of the game simulation have to be closely aligned with the learning objectives (Boller & Kapp, 2017). The core dynamic chosen for the simulation was ‘Solution’. This dynamic allows for higher-level critical thinking, in which players practise resolving conflicts and making decisions that will affect outcomes. The authors were mindful of the various game mechanics in order for the simulation to work in the classroom. Game-based learning often runs the risk of being too complicated, which might then impede students’ learning when their cognitive ability is used to figure out rules of play rather than achieve learning objectives (Boller & Kapp, 2017). While injecting fun is crucial in any game-based learning, the authors also considered the side effects of potential distractions and sought to strike a balance between fun elements and rigour in critical thinking.

Overview

In the first simulation of the July Crisis, students were assigned specific roles within the various European countries that empowered them to make decisions that would shape the course of historical developments in the lead-up to World War 1 (WW1). Students had to work ‘against time’, just as a real crisis would demand, to defuse the escalating tension among European powers in a bid to avoid war. Motivated by our success in the first simulation, the authors decided to adapt the lesson further by introducing a physical representation of the crisis through the use of UNO Stacko. The crisis selected this time round was the Cuban Missile Crisis. This simulation also allowed students to understand the motivation behind the decisions made by world leaders. Using UNO Stacko helped students to draw a parallel between the precariousness of the UNO Stacko column and the fragility of international peace and stability, and to see how actual developments during the Cuban Missile Crisis contributed to the progressive instability. Students were given authentic scenarios of the Cuban Missile Crisis, based on which they had to make decisions in order for the crisis to unfold. These decisions came with predetermined consequences that would then further destabilise international peace, represented by the unstable UNO Stacko column. Students would also understand the gravity of their decisions, with reckless actions penalised by the removal of more blocks, simulating the impact such decisions would have on world peace. Drawing such parallels between the past and the present places students in the centre of complex systems where a variety of variable factors ebb and flow simultaneously, in ways which cannot be replicated in other teaching methods (McCall, 2013, p. 13).
The July Crisis

Students were tasked to form groups of 5 to 6 (depending on the class size) prior to the lesson. Students had also learnt about historical developments leading up to WWI. During the lesson, these groups were each given a reading package which contained the background information on the July Crisis. The purpose of this was to give each group an understanding of the conditional parameters of the simulation. For example, students could not form new alliances or abandon their allies, as this would go against the historical accuracy of events.

Students next received a package containing vital information on their respective European powers (i.e. those involved in the war). This package contained the roles that each member of the group would play, with members from the same group representing the leading statesmen of an European power. These roles were meant to inform students of the level of influence that each of them had. Students were expected to influence and shape the course of development of the July Crisis based on the capacity of their assigned roles. For example, the Kaiser of Germany would have had overriding power over his generals at the start. However, as the crisis dragged on, his influence waned while that of his generals grew. These nuances in power relations were a key feature of our simulation. We wanted to expose students to the complexities of foreign policy miscalculations that ultimately led to war.

Each group was assigned a specific set of objectives to uphold in order to protect the European power’s national interests, which might or might not favour war with its rivals. Students had to chart a foreign policy course to navigate through the alliance system of Europe in a way that would best suit the respective European power’s goals. During the simulation, the teacher’s role was to prompt students to adhere to the historical accuracy of the event, while exploring possibilities that may have escaped the purview of the leaders then. For example, students decided to hold a Concert of Europe in an attempt to defuse the tension, only to realise that this was a futile effort as no leader was willing to concede his or her position. Historically speaking, no such meeting took place. All of this took place under timed conditions so as to give the students a sense of realism, as foreign policy decisions are often time-sensitive (see Figure 1).

The Cuban Missile Crisis (CMC)

This activity was intended to deliver content as well as to get the students to understand the decision-making process and the many possible outcomes of the CMC. The focus of the lesson was on the concept of brinkmanship. The authors decided to use UNO Stacko blocks as an analogy to replicate the fragility of world peace during the Cold War. Depending on their choice of action, students would have to remove a number of blocks from the column, thus simulating the impact of the actions taken by the various stakeholders on world peace. Rather than remove a predetermined and fixed number of blocks, students would have to roll a dice and remove blocks only if they hit a certain number. This was meant to simulate the element of uncertainty behind all the decisions made and the role that luck played in the crisis, essentially dramatising the ‘Fog of War’, where countries do not have perfect information about each other in a crisis (see Figure 1).

To understand the concept of brinkmanship, students were led through the 13 days of the CMC. Each day of the crisis represented a turn for the countries involved to make a decision.
They would try to make a decision that would best align with and preserve their national interests. Cumulatively, these decisions would affect the outcome of the crisis. To facilitate the process, students were given a list of possible options that were available to the decision-makers then, as well as reference to primary sources to help them contextualise their decision-making process. At the end of the simulation, students realised that decisions made during the CMC carried with them the risk of a nuclear holocaust, and that the only way to avert this crisis was for both sides to compromise. The precariously balanced UNO Stacko column left standing at the end of the simulation would serve as a grim reminder to students of how close the world came to annihilation.

To improve on lesson delivery, the authors observed each other’s lesson and how the simulation unfolded in different classes. Through this observation, it was noted that students had varying responses to the simulation, which underscores its authenticity and organic nature. Through the simulation, some classes were observed to work towards in the course of the simulation. These ‘win conditions’ were aligned to the actual outcomes of the historical developments. However, it is important for students to understand why certain historical outcomes were more likely than others due to the constraints historical actors were working with (McCall, 2013, p. 23). Thus, students would still feel that their decisions could make a difference while staying true to the historical accuracy of the simulation.

The authors unanimously agreed that the simulation of historical events is an interesting way of engaging students in the history classroom. The fact that there are various stakeholders involved in the actual development of a crisis lends itself neatly to the assignment of roles for students to re-enact the past. Secondary school students would also be familiar with simulations in academic settings, for example, the Model United Nations (MUN), where students take on the roles of international delegates to debate a given issue. The authors were also mindful that giving students too much agency could lead to ahistorical outcomes, which would then defeat the purpose of the lesson. As such, the authors deliberated on the possible choices students could make, while still allowing them autonomy in their decisions. To mitigate this problem, the authors set specific objectives for students to work towards in the course of the simulation. These ‘win conditions’ were aligned to the actual outcomes of the historical developments. However, it is important for students to understand why certain historical outcomes were more likely than others due to the constraints historical actors were working with (McCall, 2013, p. 23). Thus, students would still feel that their decisions could make a difference while staying true to the historical accuracy of the simulation.

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Students

Based on students’ feedback, it was observed that using simulation as a way to teach historical events is both engaging and enriching. As a form of engagement, students were empowered by the historical persona they took on in the simulation. Students were unanimous in agreeing that simulations made the learning of history and of the specific historical events more enjoyable. They also expressed their preference for such a learning method over conventional pedagogy such as teacher-centric lectures or even structured group discussions. While simulations are time-consuming, they offer an unprecedented opportunity for students to empathise with historical figures and feel a sense of adrenaline when having to make decisions under time pressure. Essentially, this mirrors crisis management in the real world.

Areas for improvement were discussed at length among the professional learning team during review sessions. Moving forward, the authors plan to set aside more time for students to experience the simulation, as well as time after to reflect on their learning experience. Such discussion would be enriched by students’ experiences of interacting with their peers after being immersed in a turning point in history.

The engagement level was significantly higher as students eagerly awaited the responses of their peers representing other countries. The teachers enjoyed facilitating the lesson as well, as they played the role of neutral advisors and dropped hints to students on the course of action they should take while nudging passive students to come to a decision before events overwhelmed them (Pellegrino, Lee, & D’Erizans, 2012, p. 151). As an impromptu move, one author took on the role of a ‘paper boy’ announcing the news of the enemy’s mobilisation against the country. This stirred the students into action and they called for mobilisation as well, thus setting off the regrettable outbreak of war.

The use of simulation as a learning tool is also closely aligned to the 21st century skills of critical thinking, collaboration, and global awareness. Students gain the chance to delve deeper into the political process of foreign policy-making, an area of study which does not thrive on textbook answers. The skill of critical thinking comes in when students evaluate their options before making a decision, eventually coming to the realisation that there are no easy solutions to international crises. Discussion is done in groups so that students understand and explore different viewpoints in response to an issue. As a decision has to be reached to resolve the crisis, students are, in a way, directed to reconcile differences and convince their peers of the strength of their arguments. The complexity of interactions at this level cannot be easily replicated through other modes of lesson delivery, which is why the use of simulation is a compelling approach for all history educators.

OPPORTUNITIES AND LIMITATIONS

Students

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Teachers

From the get-go, it was apparent to the teachers that the students would enjoy the learning process. It was observed that students were more engaged in discussion as they were curious about the impact of their decisions on subsequent developments. Care was taken to create a safe learning environment where students could explore different options in response to a given development. This gave students the autonomy and flexibility to exercise reasoning and decision-making at all stages of the crisis simulation. The lesson design was adapted with the joy of learning in mind. Feedback from the teachers who conducted or observed the lesson is below.

Ms Ling (Observer): “The team could consider the use of a structured framework for students to rationalise their decision in a more systematic manner. At critical points in the simulation, the teacher could also share with students in greater detail the possible consequences of confrontation so they could make a more informed decision. Overall, an engaging way of bringing history to ‘life’ in the classroom”.

Mr Chen (Teacher): “The role of the teacher immediately becomes that of a facilitator, which is better suited for student-centric learning. Twist and turn in crisis developments could be played out in a simulated learning environment. It is interesting that developments happened simultaneously which will then all culminate in key turning points where students have to make critical decisions”.

Mr Emmanuel (Teacher): “Using crisis simulation as a teaching strategy is less prescriptive and allows students to explore alternative routes that could have been taken. The emphasis is on the process rather than arriving at the outcome. It allows students the room to first rationalise their decisions, then justify it to their fellow members in a bid to rally for support, mimicking what leaders would do in a real world setting. This is essential for critical thinking and strengthening their argumentation skills in speech and in writing”.

The merits of this approach have been discussed at length in earlier paragraphs. However, the authors are mindful that there are areas for improvement in both the design and implementation of this lesson package. For one, it would be ideal if the simulation could be carried out across 2 hours instead of 1 hour, to allow both the teacher and students to be more deliberate in the learning process. There were several opportunities for the teacher to expand on the choice of action taken by students, yet time constraints meant that these were not fully utilised. Students may also require more scaffolding in terms of contextual knowledge, which would then allow them to better appreciate the nuances of the historical context. Furthermore, given the limited roles that one crisis simulation affords, it was not possible to have every student engaged at the same level. For example, during the Cuban Missile Crisis, students who represented the international community took on a more passive role compared to their peers who represented the superpowers and Cuba.

CONCLUSION

Given the current emphasis on examinations in the education landscape, both teachers and students would feel insecure if simulation were to replace conventional modes of lesson delivery. Instead, simulation serves to play a complementary role that looks to inject excitement into students’ learning experience in the history classroom. Students will still need a strong grounding in content understanding for examination purposes, which simulation may not be well suited for. However, using simulation helps students to be more conscious of their thought processes and to respond accordingly to input from different sources, such as their peers and game materials.

It is also acknowledged that a simulation model cannot be applied to all historical case studies seamlessly and, therefore, it is up to the teacher to decide what is best suited to his or her students’ profile and curriculum needs. The authors would like to reaffirm that the benefits of this pedagogical approach far outweigh the cost, in this case, time and preparation. It is strongly encouraged that simulation be widely adopted in the teaching and learning of the humanities as it helps students to develop empathy and insight into human behaviour, which is otherwise challenging to replicate in other learning contexts.
REFERENCES


ABOUT THE CONTRIBUTORS

Jason Chen has been teaching History in Dunman High School for the past 6 years. He believes that History should be accessible to all learners regardless of their proficiency or interest levels. His passion for the subject has led him to introduce game-based learning in his lessons to excite his students. He is currently pursuing his Master of Arts in Humanities Education.

Andrew Emmanuel has been teaching History at Dunman High School for the past 6 years. He believes that every student can learn and wants to do their best. His passion for history and teaching is only rivalled by his love for comics. It is his wish that the next great comic book will be set in Singapore’s past and be drawn by one of his students.
Chop! A Card Game to Teach Deforestation

Ang Cheng Ai Tessa
Cedar Girls’ Secondary School
Tung Wai Kiong Derek
East Spring Secondary School

Having played numerous board games of different genres, the contributors acknowledge that games have multiple benefits. Not only do they have the element of fun, they also help to develop important 21st century competencies, such as social and critical thinking skills.

However, infusing games into classroom teaching can sometimes be a challenge, as it is difficult to find a suitable game that is perfectly tailored to the needs of the Singapore Geography syllabus. Often, teachers have to make a conscious effort to highlight important elements of the game and its relevance to the syllabus. For instance, one can argue that the board game Pandemic can be used in the teaching of an upper secondary topic, Health and Diseases, but the game does not aid in answering key guiding questions. This is without even considering the amount of time needed to teach and play a complete game.

This gave the contributors the motivation to create a card game that was easy to teach, set up, play, and, most importantly, was relevant to the Geography syllabus.
As we prepare students for a future that is largely unknown, where knowledge and jobs eventually become obsolete, we can all agree on the importance of inculcating values and competencies, and achieving outcomes that will help students to adapt to a future where change is the only constant. These competencies and outcomes are highlighted in the Singapore Ministry of Education’s Framework for 21st Century Competencies and Student Outcomes.

Some researchers, including Raut (2014), have highlighted the use of board games as an engaging method to teach 21st century competencies, especially games that combine content with strategy. Others echoed the effectiveness of board games in learning. Pannese & Carlesi (2007) highlighted that the high interactivity of games ensures a high degree of attention, very much in line with the notion of making lessons more engaging for students, and of developing the competencies of communication and collaboration. The game was created with the intention of teaching the topic, Tropical Rainforest, in a more engaging manner, such that students would remember it through experiential learning.

**LITERATURE REVIEW**

About the Game

*Chop!* is a game that can be played by 2 to 4 students. It comes with 43 playing cards, 25 tree cards, 16 event cards and 4 role cards. Each game lasts an average of 15 minutes. The game ends when the last event card is played. To win the game, one or more of the following conditions must be fulfilled:

- At least 1 tree remaining after the last event card. (Beginner)
- At least 1 tree remaining, and the winning condition of the assigned role is fulfilled. (Advanced)

Each student is randomly assigned one of the four roles which have additional but different winning conditions. This represents the different interests of the stakeholders. The different stakeholders and their winning conditions are as follows:

- The Environmentalist
  Wins when there are at least 5 trees cards remaining.

- The Indigenous People
  Wins when there are at least 2 trees containing the images of indigenous people remaining.

- The Businessman
  Wins if the player has the most amount of money at the end of the game.

- The Government
  Wins when at least 2 other stakeholders have met their winning conditions.

The following are the steps taken during a player’s turn:

1. Open an *Event* card which highlights a cause of deforestation. The *Event* card indicates the number of trees that must be cut down. The player will then turn over the number of tree cards as indicated, highlighting a stump. This signifies that a tree has been cut down.
2. A player can play up to 3 playing cards from his or her hand of 5 cards. The playing cards include money cards as well as cards that help to manage deforestation. Money cards must be used to ‘buy’ cards that help manage deforestation and ensure there are trees left in the rainforest.
3. A player will replenish his or her hand to a maximum of 5 cards (unless otherwise indicated during the deforestation stage in Step 1).
The 3 Stages

For both schools, the 3 stages were as follows:

1. Pre-Gaming Phase

In this phase of the game, students were separated into groups. Special consideration for groupings may be applicable depending on the dynamics of the classroom. It may also be necessary to lay down rules and regulations to ensure that students are responsible in the handling of the cards, and also to create a safe playing environment, as the contributors did. After this, the rules of the game, setup, and gameplay were introduced to students.

2. Gaming Phase

In this phase of the game, students got to interact and strategise their gameplay. The contributors were to take on the roles of facilitator and moderator, not only to ensure that the rules of the game were adhered to, but also to probe and question students to bring more depth to the game.

3. Post-Gaming Phase

This phase of the game was, in the contributors’ opinion, the most important stage, as it allowed students to reflect on decisions made during the game and areas for improvement. It was also an important stage for the contributors to touch on salient points and to cull learning.

IMPLEMENTATION (JANUARY – OCTOBER 2017)

Lower-Progress Students

The game was implemented in Normal (Academic) classes in East Spring Secondary School with the primary aim of increasing student engagement and instilling a joy for learning. The secondary aim focused on bringing a real-world scenario into the classroom, involving the introduction of different stakeholders in the preservation of the tropical rainforest, and also making the complexities involved in the decision-making process more visible.

The game was used as a ‘sparking curiosity’ activity prior to the sub-topic on strategies for the conservation of the tropical rainforest. The first lesson was used to explain the rules and go through the gameplay, and for students to have a trail run. After this, students played a cooperative game with the aim of satisfying the winning conditions. The next lesson involved the introduction of different stakeholders and individualised winning conditions, which added a layer of complexity and realism to the game. The teacher acted as a facilitator throughout the whole process, not only ensuring that the game was played according to the rules, but actively questioning why certain actions were taken to make the students’ thought processes more visible.

The whole process ended with the students answering a reflection worksheet. This would not only help them articulate their actions taken during the game, but also help them see the relevance of the game to a real-world problem happening globally.

Post-Game Observations

Two key observations were made while grading students’ reflections. The first involved a seemingly superficial response by students. As money of lower denomination was used during the game, many students argued that the process of conserving the tropical rainforest was a lot costlier than what the game had portrayed. Upon deeper reflection, this low-level response highlighted the pre-existing knowledge that students had. They knew of the high cost and difficulties involved in the conservation of the tropical rainforest. Students, however, were not polled on the actual cost involved, leaving the question of whether students were aware of the scale involved up for debate.

The second observation involved real-world complexities associated with decisions made during the game. As students took on the roles of different stakeholders later in the game, which included individualised winning conditions, they stressed the difficulty of fulfilling both individual and cooperative goals simultaneously. Students acknowledged the complexities involved in this role-playing portion of the game and the compromise needed from all parties in the process of conserving the tropical rainforest.
Higher-Progress Students

A Lesson Study with 2 cycles was carried out at Cedar Girls’ Secondary School to determine how well a decision-making card game would help students to analyse and compare strategies so that they could craft a well-reasoned conclusion for their Open-Ended Question (OEQ). Each cycle had a panel of teachers sitting in to gauge the level of students’ learning. The Lesson Study was evaluated based on the OEQ answers of students, their reflection worksheets, and feedback from the panel of teachers who attended.

Secondary 1 students are new to the OEQ. Most are able to master the PEEL (Point–Evidence–Explanation–Link) paragraphs for a well-explained answer. However, this only enables them to reach Level 2. To reach the highest Level of 3, they are required to write a well-reasoned conclusion which compares the factors, strategies, and/or measures based on a criterion, or provide solutions. This requires critical thinking and analysis. 69 students from 1H and 1M were asked to write a conclusion to the question: “Evaluate public education and reforestation as ways to manage deforestation”. Students wrote generic statements for their conclusions, such as “In conclusion, there are advantages and disadvantages”, or merely summarised what they had already written in their explanations. As seen in Figure 1, out of the 69 students, only 3% in 1H and 6% in 1M were able to write well-reasoned conclusions to attain Level 3. The majority were stuck at Level 2 as their conclusions were merely summaries of their answers.

Figure 1: Students’ OEQ Level Attainment before the Game
Post-Game Observations
During the Lesson Study lessons, students played the game and completed a reflection worksheet. Examples of the guiding questions and the learning points are as follows:

Question: Why should players pool their money in order for the Protection of Forested Area and Reforestation cards to work?

Students were able to realise that different stakeholders such as the government, businessmen, environmentalists, and indigenous tribes would have to work together in order for laws to be passed and implemented successfully to protect forested areas. They also had to come together with both time and resources to implement reforestation.

Question: For the public education card, why does only 1 player need to pay?

Students were able to realise that, for public education to be effective, it has to start with the individual. Each person must want to change his or her behaviour and lifestyle to conserve the rainforest.

Question: Which strategy card would have won the game? Why was it difficult to play that card?

Students were able to see that the Protection of Forested Area card would have won the game. However, most groups did not play the card as it was expensive, and it would have taken time to build up enough resources. Furthermore, everyone’s cooperation was required to pool money to play the card. However, not everyone cooperated, because each role had its own objective for winning the game. Students can relate this to the real-world context, where different stakeholders have different vested interests, which makes it difficult for them to come together to implement a solution.

After the Lesson Study was completed, the conclusions given had more depth and analysis. Examples of students’ conclusions include the following:

“In conclusion, both strategies are interdependent. Public education will reduce the demand for trees while reforestation would increase the supply of trees. Therefore, this 2-pronged approach is more effective.”

“In conclusion, protection of forested areas is more effective than reforestation in terms of time taken to see the results. Protection of forested areas will immediately protect the trees from being cut down once the law is passed. However, reforestation will take 10 to 15 years for the trees to grow to canopy layer.”

As seen from these conclusions and Figure 2, there has been an improvement in the percentage of students who were able to attain Level 3 for their OEQ. Instead of mere summaries, more students were making an attempt to evaluate their arguments using criteria such as time and money.

Figure 2: Students’ OEQ Level Attainment after the Game
Chop! is a versatile game as it can be used for lower- and higher-ability students. It can be used in any part of the scheme of work, from a ‘sparking curiosity activity’ to an activity that helps to conclude or recap the topic, and can even be used to teach answering skills like evaluation. It covers a major portion of the topic, Tropical Rainforest, where it flushes out the causes and impact of deforestation, and the strategies employed to combat it.

This game allows students to do perspective-taking and try to apply academic knowledge to the real-world context. Students would realise that different stakeholders have different interests, which makes it difficult to manage deforestation. This would hopefully inspire students to be concerned citizens and to take an active role in solving the issue of deforestation by using less paper or educating others on this issue.

However, when using games in classroom teaching, one key concern is time. Teachers would have to first teach the game to the students, which might take up precious curriculum time. One possible solution could be to identify group leaders and to have a session outside curriculum time with these group leaders, where teachers would first teach the leaders and allow them to play the game to get a feel of it. During the lesson, the group leaders would then assist in teaching the game to the group members. This would hopefully minimise the number of questions posed to the teacher as the group leaders would be able to answer them first.
CONCLUSION

Although using games in the classroom can be challenging and time-consuming, the benefits of using games in the classroom far outweigh the drawbacks as they are interactive and collaborative in nature. Students are highly engaged and are able to perspective-taking. The textbook comes alive for them and they are better able to internalise the concepts.

Should any Geography teacher be interested in implementing this game in his or her classroom, feel free to approach the contributors for the resources, such as a soft copy of the cards, PowerPoint slides for the rules, and reflection worksheets from both schools.

REFERENCES


ABOUT THE CONTRIBUTORS

Derek Tung is a Geography and Physical Education teacher at East Spring Secondary School who has been teaching for 5 years. Tessa Ang is a Geography teacher at Cedar Girls’ Secondary who has been teaching for 3 years.

Derek and Tessa are married and love to travel the world together. In their free time, they love to play board games and are inspired to think of more engaging and innovative ways to teach Geography through games.
Experiential Learning in Art through Information and Communication Technology (ICT) and Photography

ABSTRACT

This paper will explore the use of authentic experiential learning in Art for two types of lessons, namely the use of ICT (Information and Communication Technology) in Study of Visual Art (SOVA) lessons, and the use of the Design Thinking framework and design briefs to improve students’ research and idea development skills in Studio lessons.

We will share how, in a SOVA lesson, students were engaged in independent experiential learning about public art and sculpture in Singapore’s Central Business District (CBD). This granted them the opportunity to not only see actual artwork, but also to work in groups to complete field research on the artwork. ICT was used to enhance the experience of learning, where students were given a list of artworks marked out on Google Maps for them to locate around the CBD. Instagram was also used as a platform for teachers to get real-time updates on students’ progress.

For the Studio lesson module, experiential learning was carried out through multi-sensory observations and photography. This paper will share how instructions were crafted as design briefs to encourage more open and creative interpretations of the tasks, with these design briefs presented to students through various means to promote student engagement and interest in the tasks.

INTRODUCTION

In the course of our teaching, we noticed that many students lack authentic experiences and usually turn to second-hand resources and the internet for research. Hence, we aimed to address these issues and cultivate good learning habits through experiential learning at assigned locations. With the help of guidelines set out in the assignment brief, we engaged students’ multiple senses on site at the locations, where they were able to see beyond just the visual aspect of contemporary art and gained inspiration from multi-sensory artworks common to new media art, such as installation art, sound art, performance art, and video art.

Experiential learning also focuses on the idea of ‘learning by doing’, which is one of the fundamental ideas of the Design Thinking framework. Therefore, it was a natural fit with the module’s approach of experiential learning.
ICT-INFUSED STUDY OF VISUAL ART (SOVA) LESSON ON PUBLIC SCULPTURE

Instagram is a popular social media site commonly used by students these days to share images. Since it is a familiar digital platform, we felt that Instagram is therefore a suitable engagement tool for our students. In addition, the timestamp function on Instagram was also a means to monitor the students’ progress on the tasks, given that it is not possible for the teachers to accompany every single group all the time.

We believe that it is only when students see the actual sculptures that they will get a sense of the scale, texture, location, and context in relation to public spaces. Only in this way can they better understand the topic of Public Sculpture. Hence, this assignment is designed such that students are to complete the tasks outside the usual classroom environment, with the help of the map (Figure 1), activity sheet (Figure 2), and assignment brief provided.

Students were tasked to locate all the sculptures indicated on the map, take selfies with them, and upload these onto Instagram with the designated hashtag to prove their presence. They were also encouraged to locate sculptures that were not listed on the assignment brief and submit the images as bonus sculptures. After the sculpture trail, they were tasked to consolidate their research, findings, and observations, and share them with the class in the next lesson. An essay to be written as homework, modified after a past-year A-Level examination question, could also be given after the lesson to check on students’ understanding.

CHALLENGING LIMITS AND FINDING CREATIVE SOLUTIONS THROUGH DESIGN THINKING

After a few years of teaching, we noticed a few problems:

• Students rely a lot on expressing their ideas and research in text and they are generally not confident in exploring these ideas visually on their own or are unable to.
• There is an overuse of and overdependence on secondary sources and the internet for ideas. Students merely adapt these ideas for their projects, which causes the lack of depth in their ideas and concepts.
• When idea generation and conceptualisation is not explicitly taught, students have difficulty developing original ideas, as well as in jump-starting their research and idea generation process.
• Most of the students cannot appreciate the need for exploratory processes which build up to the final work, resulting in works that tend to be conceptually weak.
• Students are often too preoccupied with the aesthetics of the final work and spend too long a time procrastinating if they deem their ideas not good enough.
How can students improve on their research ability and idea development skills, and build their creative confidence? With this idea in mind, we created a photography module based on the Design Thinking framework titled Pushing the Boundaries of the Printed Image. This module employs a structured approach to guide students on how to generate and develop their ideas through images gathered from their research. We wanted to challenge students to engage with photography not just from the traditional viewpoint of mere documentation, but to push the boundaries of the medium of photography, treating it as a highly expressive medium with the potential to be presented in innovative forms. To achieve this, activities in the module provide scaffolds to increase students’ exposure to new media representations in contemporary art. Some contemporary, interdisciplinary, fine art photographers we introduced include John Clang, Robert Zhao, Jing Quek, and Osang Gwon. The final task requires students to arrive at a three-dimensional (3-D) form, even though the starting point is photography, a predominantly two-dimensional (2-D) medium. This is to stretch the students’ thinking and problem-solving skills.

This lesson unit is planned for one term, targeted at Junior College 1/Year 5 students, where each studio lesson is 3 hours. The tasks can be adjusted to suit secondary school students. Students would have completed the module on 3-D media and be exposed to techniques such as creating Styrofoam sculptures and papier-mâché and casting plaster forms before this module.

This module also aimed to heighten students’ awareness that photography, although predominantly in digital format in today’s contemporary context, has other non-digital forms of reproduction through non-digital, analogue processes like silk-screen printing, cyanotype, and physical manipulation techniques.

What is Design Thinking?

According to Tim Brown, CEO of global design and innovation company IDEO, “Design Thinking is a human-centered approach to innovation that draws from the designer’s toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success.” (IDEO, 2018)

As such, Design Thinking is a mindset and process (Figure 3) that can be used to develop students’ creative problem-solving skills as it forms a structured approach to generating ideas and encourages students to look at problems from new perspectives.

![Figure 3: Design Thinking 101](https://www.nngroup.com/articles/design-thinking/)

Source: https://www.nngroup.com/articles/design-thinking/
Application of the Design Thinking Framework to the Module Created

- **Empathise Phase**
  In the first assignment brief, students were tasked to take photographs and observe enclaves frequented by migrant workers. They were encouraged to interact with them if possible, in order to get a feel of some of the issues migrant workers face, and understand how and why they do certain things, their worldview, and what is meaningful to them.

  This phase is primarily about understanding the people in the context of the assignment, which incorporates ideas of Realism and Social Realism in the work. This helps students become more aware of what issues could be or need to be explored.

- **Define Phase**
  Students defined the issues that their observations indicated, based on what they had learnt about the migrant worker community at their assigned migrant worker enclave. This helped them make sense of the wide scope of information they had gathered.

  The goal of the Define mode is to help students develop a point of view.

- **Ideate Phase**
  In this phase, students concentrate on idea generation, where they are encouraged to ‘go wide’ in terms of concepts and outcomes and not just stick to the initial idea. This phase requires students to use sketching to record their ideas. This allows room for new ideas to develop as students do not have to worry about forgetting the idea and will not have that anxiety congesting their thought processes. Sketching also allows for easier communication of their ideas. Another key point at this stage is the deferment of judgement, where students are prevented from shelving early ideas which they usually think are “not good enough” or “a dumb and stupid idea”.

- **Prototype Phase**
  Students are also guided in the prototyping process where they are encouraged to try out techniques physically instead of just thinking about them, giving them an authentic sense of the feasibility of their ideas. Failure to achieve what they originally had in mind here is part of the process of discovery.

  This phase corresponds to the subsequent assignment briefs on creating texture swatches and applying physical manipulation of the photographic image, where students were given the freedom to recreate textures and physically manipulate the photographs they took with any method or technique, and material and media of their choice. This phase thus acts as the catalyst for students to go beyond viewing the presentation of photography from a flat, two-dimensional perspective to a three-dimensional one.

  - **Note:** The Ideate Phase and Prototype Phase go hand in hand and can happen concurrently, moving back and forth through the phases.

- **Testing Phase**
  This is the phase where students solicit feedback and constructive criticism about the ideas and prototypes they have created from peers and teachers. This is usually done through one-to-one consultations and weekly class critiques, as well as the final end-of-project critique, before the works are exhibited at the exhibition at the end of the semester. The testing phase is also another opportunity for students to get new insights from peers through the various interpretations offered by their classmates, as well as suggestions on what can be improved or done differently.

**Mode of Instruction – Assignment Briefs**

The utilisation of an assignment brief for weekly tasks provides clarity, yet also allows room for creative interpretations of the brief. Students are thus encouraged to come up with any creative solution that fits the parameters, giving them the opportunity to push boundaries but still keep to the basic deliverables.

Assignment briefs were also given out using different forms throughout the module to allow for variety, novelty, and suspense. This gets students excited, creating a more positive and creative environment for ideas to flow.
Introduction of Manageable Weekly Task

Instead of giving instructions to students at the beginning on what the final assignment would be, to be followed by a few weeks of research and idea development to achieve the intended result, we decided instead to give out weekly tasks without disclosing the final assignment.

These weekly tasks aimed to scaffold the students’ development of ideas, allowing them to focus on the tasks at hand, and thus helping them not to over-analyse and restrict the potential of ideas. The change also allows a certain degree of freedom as students do not need to consider whether what they are creating is good enough or in line with the final assignment, allowing for breadth of exploration. Information on the final assignment is only given at a later stage in the module, to prevent students from being too fixated on the end product, and thus causing them to overlook the exploration and developmental process of their chosen theme.

National Education (NE) and 21st Century Competencies (21st CC)

Focus on NE was introduced through the module in a subtle manner, despite it being one of the major focuses in the module. Students discover the NE and 21st CC connections and issues themselves through self-directed exploratory means. The teacher only further emphasises the NE ideas later in the classroom when the students come back to share their findings with the rest of the class.

The initial assignment brief only required students to observe their assigned location, and set out simple tasks like having a meal there or talking to someone at the assigned location. Through the observations they made, students discovered Singapore by visiting places that they would not usually go to or would usually overlook. This built empathy towards and understanding of the different communities and cultures in Singapore.

This module therefore encourages civic literacy, global awareness, and cross-cultural skills, developing students’ social awareness and nurturing them as concerned citizens who are critical and creative thinkers through innovation skills (Figure 4).

Figure 4: Framework for 21st Century Competencies and Student Outcomes
Source: https://www.moe.gov.sg/education/education-system/21st-century-competencies
CONCLUSION

As the instructions in this module are purposely left vague and open to interpretation, students come back with very interesting observations of the locations assigned to them. However, this non-guided, open-ended format has also led to students sometimes overlooking main traits of the space, such as features that are unique to the locations and the people who patronise the area.

Thus, we learned that some form of structure or explicit direction is still required in the instructions given to maximise student learning.

For example, instead of sending students out to gather their research photos on their own, a ‘guided tour’ could be conducted by the teachers first to highlight important features of the different locations, to ensure that they are not missed out by the students. Small activities could also be conducted during the Learning Journey, where students will be asked to indicate to teachers the areas that are of interest to them at the start of the Learning Journey. Thus, instead of teachers giving briefings on the locations, they will facilitate meaningful discussions and ensure that the students do not miss out important features of the identified locations.

REFERENCES


ABOUT THE CONTRIBUTORS

Tan Yu Shi has been teaching Art at the Junior College level for the past 4 years. She believes that Art education does not only involve the teaching of art-making techniques, but, more importantly, it provides the opportunity for students to use art as a basis for inquiry, critical thinking, and practical application. The act of art-making thus becomes a creative process that helps to design meaningful solutions to the problems that students face or the questions that they may have about the world they live in. Hence, she believes that Design Thinking is an important mindset to cultivate among students as it is an empowering way to solve problems, and the skillset is transferable across disciplines.

Brian Lee has taught Art at the Junior College level for the past 4 years. He believes that Art as a subject not only trains students in acquiring technical skills in creating artwork, it also develops students’ critical skills in how they view the world around them. Only through providing students with the necessary observation and inquiry skills in tandem with the technical skills in art can students engage with and respond to their society through artwork that is creative, expressive, and personal.
The aims of the project are as follows:
- to enable teachers to teach for enduring understanding through the class group discussion and evaluation of each other’s performance, similar to a more interactive masterclass;
- to improve students’ Listening Perception and Performance skills so that they are aware of their strengths in performance, the areas that need attention, and the areas of interpretation that are stylistically acceptable;
- to engage students in more active discussion by having them listen to each other perform live, then watch videos of their performances in class, followed by a discussion on the areas to be focused on, rather than a bar-by-bar approach; and
- to target student character development, an important aspect of holistic development. This development would be indicated by:
  • students taking the initiative to be more reflective in their performance playing; and
  • students exercising sound decision-making and independent thought in planning their performance repertoire.
Research has shown that the quality of one’s practice is the best indicator of achievement (McPherson, 2005; Williamon & Valentine, 2000). Due to the limited class time available for mentoring each student in the performance aspect of the curriculum, it is critical for students to develop self-regulation and independence so that they can maximise the quality of their own practice time. Research has also shown that music students are largely unsophisticated in practising at the beginning, but acquire practice strategies and metacognitive strategies as they gain more experience (Hallam et al., 2012; Leon-Guerrero, 2008; McPherson, Davidson, & Faulkner, 2012). It is thus essential for us to delve into how teachers guide MEP students through the fortnightly practical tutorial and lecture sessions, and how a self-regulated practice routine can help our students engage in more focused and deliberate self-practice.

Self-regulated learners have been characterised as being “metacognitively, motivationally, and behaviourally active participants in their own learning process” (Zimmerman & Martinez-Pons, 1988). They are also able to successfully negotiate the continually interacting learning phases of forethought (goals, self-beliefs), performance (observation of the self in the moment, application of strategies), and self-reflection (self-evaluation/ awareness, self-judgement, attribution) (McPherson & Renwick, 2011; Zimmerman, 2000). These are critical thinking and decision-making skills that can have significant impact on students’ performance repertoire and mental preparation prior to their performances.

The practice logbook designed by the Senior High Music teachers is largely based on the following guiding principles:
- **to build up students’ self-efficacy**, as research looking into the practising of intermediate (McCormick & McPherson, 2003; McPherson & McCormick, 2006) and advanced (Nielsen, 2001) instrumentalists has found significant relationships between self-efficacy beliefs and practice strategy use and time spent practising;
- to provide a **general self-reflective practice routine and toolbox** to guide students in their practice sessions so as to effectively maximise their practice time without relying on teacher feedback to do so. Intentional, goal-directed strategies (e.g. chunking, whole–part playing, skipping to critical sections, using a metronome, slowing) have tended to be correlated with performance achievement (Duke, Simmons, & Cash, 2009; Miksza, 2011);
- **to track each student’s progress** on the achievement of their musical goals over time (e.g. progress from more bite-sized technical goals to more musical ones); and
- to establish an avenue for students to **record teacher’s feedback** (homework assignments on practice goals) during their fortnightly practical tutorial in order to allow the alignment of teacher’s intentions and students’ self-practice.
METHODOLOGY

Design of the Logbook

Aesthetically, the logbook was designed to resemble the Henle and Barenreiter scores with each student’s name inserted where the composer’s name would normally be placed. This was a small but significant move as students felt encouraged and developed a sense of pride in seeing their names likened to a composer’s.

The logbook was designed to be relevant to students and accessible. The theme was Harry Potter, and the first page featured The Mirror of Erised, used as a prompter for students to pen down the goals they wanted to achieve in their performances (see Figure 1).

A template was also given showcasing different memes for students to list their strengths, their hurdles and challenges, the current strategies adopted, and the feedback shared by their MEP teacher and private performance teacher.

The book also featured a rubric system based on the A-Level Performance Studies rubrics. As this idea will slowly be applied to the lower levels, teachers teaching the lower levels can opt to edit the text to be age-appropriate (see Figures 2a and 2b).

Grade yourself by circling from 1 (poor) to 5 (very good) and evaluate your performance in the following areas:

<table>
<thead>
<tr>
<th>Fluency and accuracy</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitch/notes</td>
<td></td>
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<tr>
<td>Rhythm</td>
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<tr>
<td>Tempo</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Dynamics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variety/even tone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coordination</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range of technical skill</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you understand my part as an ensemble?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can I support the soloist?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance markings and conventions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Performance markings and conventions</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Dynamic</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Tempo</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Expression</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Tempo</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Expression</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Figure 1: The Mirror of Erised
(Students’ Performance Goals)

Figure 2a: Rubrics for Self-evaluation

Figure 2b: Rubrics for Self-evaluation

The final few sections allowed students to record what they had learnt from listening to or watching other performers on CDs or YouTube.
Implementation of Lesson Package

The lesson package was conducted over 20 weeks in Semester 1. Students were first allocated a week each to present their performances. This could be in the form of a live performance or a video recording of their own playing, whether during rehearsal or during the formal examination. It was also important to create a safety net so the students would feel comfortable sharing their own thoughts, and this was achieved by having the teacher explain the rationale and purpose of the package to students. Students would have reviewed their performances in their own time before presenting.

Through the subsequent discussion in the performance lecture, students were asked to share their reflections. The students would need to share the rationale for rating their own playing as such and classmates would share whether they agreed or disagreed with the ratings. Questions like “What are some of the areas you feel confident in?”, “What are some of the areas you find challenging?”, and other prompting questions were used. These are important in motivating students to question their choices and thoughts at a deeper level, which in turn develops students’ critical thinking and self-awareness.

Through embarking on this project over 10 weeks, students would slowly start to be more independent in making rational decisions on their choice of pieces, be able to explain the rationale for their choice of repertoire, and be fully aware of their strengths and areas for improvement. Additionally, they would be more proactive in listening attentively to their own playing and that of others, which indirectly would also help them develop a sense of empathy and social awareness as they communicated their comments to their classmates.

Data Analysis

Information on students’ learning and the effectiveness of this learning package was gathered in four areas. These four areas are:

1) behavioural observation of students during class and at tasks assigned;
2) examination and test results;
3) students’ responses on worksheets and exercises; and
4) quantitative and qualitative feedback on the learning package by students (via survey and reflections).

Prior to embarking on the lesson package, 71.4% of the students hovered at mid-B and could not improve much by the end of Year 5. After starting the package, the weaker students (Students C, F, and G) were able to carry out more independent learning and became comfortable recording their performances during practice sessions. This was especially so for Students E and F, of whom the latter was proactive in seeking to improve her level of technique and attention to detail. It was also observed that the weaker students became more proactive in giving comments in class, especially Student E, who became more confident in his performance and could contribute to helping his classmates.

As 100% of the students opted for the Performance major, the 40% weightage of their results is of great significance in their overall examination results. While the students naturally improved in other aspects due to experience, the strategies applied in the Performance category significantly affected the final H2 Music result.

In terms of the overall examination and test results, there were considerable improvements for the majority of the students in the class, including both the weakest and strongest students. Tables 1 and 2 below illustrate the results, comparing the Year 5 Promotional Examination (2016) and the major examinations in Year 6 (2017). (Note: The 2017 results were obtained after the learning package had been implemented.)
Table 1: Overall Examination Results at Year 5 (2016) and Year 6 (2017)

<table>
<thead>
<tr>
<th>Name</th>
<th>2016 PROMO</th>
<th>2017 MCT</th>
<th>2017 MYE</th>
<th>2017 PRELIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>65.4</td>
<td>71.6</td>
<td>67.2</td>
<td>75.6</td>
</tr>
<tr>
<td>B</td>
<td>67.4</td>
<td>70.6</td>
<td>71.2</td>
<td>73.2</td>
</tr>
<tr>
<td>C</td>
<td>64.2</td>
<td>61.8</td>
<td>72.0</td>
<td>74.9</td>
</tr>
<tr>
<td>D</td>
<td>70.2</td>
<td>76.4</td>
<td>78.2</td>
<td>81.3</td>
</tr>
<tr>
<td>E</td>
<td>70.6</td>
<td>70.2</td>
<td>75.2</td>
<td>80.1</td>
</tr>
<tr>
<td>F</td>
<td>66.2</td>
<td>68.8</td>
<td>67.8</td>
<td>73.7</td>
</tr>
<tr>
<td>G</td>
<td>68.8</td>
<td>67.8</td>
<td>71.8</td>
<td>77.9</td>
</tr>
</tbody>
</table>

Table 2: Performance Component Results at Year 5 (2016) and Year 6 (2017)

<table>
<thead>
<tr>
<th>Name</th>
<th>2016 PROMO</th>
<th>2017 MCT</th>
<th>2017 MYE</th>
<th>2017 PRELIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>71.0</td>
<td>78.0</td>
<td>79.5</td>
<td>86.5</td>
</tr>
<tr>
<td>B</td>
<td>69.5</td>
<td>73.5</td>
<td>78.5</td>
<td>82.5</td>
</tr>
<tr>
<td>C</td>
<td>67.5</td>
<td>65.5</td>
<td>71.5</td>
<td>79.0</td>
</tr>
<tr>
<td>D</td>
<td>78.0</td>
<td>85.0</td>
<td>82.0</td>
<td>88.0</td>
</tr>
<tr>
<td>E</td>
<td>70.0</td>
<td>74.5</td>
<td>76.0</td>
<td>85.0</td>
</tr>
<tr>
<td>F</td>
<td>62.5</td>
<td>67.0</td>
<td>69.0</td>
<td>76.0</td>
</tr>
<tr>
<td>G</td>
<td>67.5</td>
<td>58.0</td>
<td>69.0</td>
<td>78.0</td>
</tr>
</tbody>
</table>

Overall, the final results in Table 1 show students’ grades as all As, ranging from lower to higher As. This reflects a significant improvement from the 2016 overall results and their progress across the year. The various components (barring other factors during the test stage) show a steady improvement for most of the students, with 4 Bs and 3 As at the 2016 Promotional Examination to 1 C, 2 Bs, and 4 As in the March Common Test, to 2 Bs and 5 As in the Mid-Year Examination, and, finally, a healthy range of As in the Preliminary Examination.

Some quantitative feedback collated with regard to the logbook included the following:
- 85.7% of students agreed that it allows them to articulate their performance goals;
- 85.7% of students agreed that it is useful in guiding them on a self-reflective practice routine;
- 100% of students agreed that the breakdown of self-evaluating criteria under the four assessment areas allowed them to be more familiar with the national assessment rubrics;
- 71.4% of students agreed that the page on suggested practice strategies provided is useful in helping them overcome some of the challenges faced without the need to overly rely on teacher’s feedback;
- 71.4% agreed that the logbook allows personal tracking of progress over time;
- 100% agreed that it allows them to record their teacher’s feedback and to better work on the areas discussed;
- 100% agreed that they are more comfortable recording their own performance during practice sessions to better reflect on their playing through watching and listening to the playback;
- Most students (71.4%) felt that the logbook has encouraged them to seek improvement in terms of critical listening to their peers’ performances, as well as observation of musical details (71.4%), followed by seeking improvement in performance techniques (57.1%). It is observed that the logbook was less successful in terms of guiding students in the stylistic requirement of the works (28.6%), in understanding the works they perform (14.3%), and in understanding how to improve based on the assessment criteria (14.3%).

In terms of the logbook being used in conjunction with the practical lecture, most students felt more comfortable receiving and giving feedback, and started to take ownership of the refining of their performance component. Some data gathered is as follows:
- 85.7% agreed that the lessons and logbook allowed them to be more proactive in being aware of their own playing ability and improving on it;
- 71.4% agreed that the lessons and logbook allowed them to develop ownership of their learning;
- 85.7% agreed that they are more comfortable receiving comments from their peers during the lessons;
- 100% agreed they are more comfortable giving feedback to their peers during these lessons.

In terms of the design of the logbook:
- 100% agreed that they like the personalised cover page design of the logbook which resembled the Henle and Barenreiter scores;
- 100% also agreed that they like the concept and design of the inner pages of the logbook.

In terms of the areas for improvement, some areas cited included having more detailed practice tips, as well as the inclusion of some guidance to encourage independent research into and the study of the pieces in order for students to gain a better understanding of their background and inner workings. This is in line with the survey results quoted above, where most students felt the logbook did not deliberately guide them in enhancing their understanding of the works. Other design suggestions included providing more writing space and ring binding the book for ease of use.
Overall, there is evidence that the practical logbook package enhanced and enriched students’ musical understanding of their own performances and that of others. They were encouraged to think critically and exercise greater evaluative skills in relation to their choice of repertoire, and could understand their strengths and areas for improvement. The music component of Performance is one that is rigorous, is conducted over a long period of time, and requires patience, maturity, grasp of technique, and listening perception skills to execute a high level of performance. Students were also more confident in performing for the public. Moving forward, the department intends to apply this similar reflective aspect to the Junior High levels for both the MEP and the General Music Programme (GMP), albeit modified to be age-appropriate.

REFERENCES


ABOUT THE CONTRIBUTORS

Debbie Tan Ai Ling has been teaching A-Level Music for 15 years, with 2 years at the Curriculum Planning and Development Division at the Ministry of Education, Singapore. She is currently the Subject Head of Music at Dunman High School. Her interests include pedagogical approaches in learning music, Japanese music, and ethnomusicology.

Yick Jue Ru currently teaches in the Music Elective Programme (Years 3 – 6) at Dunman High School. She has presented and published music papers based on her Master’s thesis research. Her areas of interest include the study of musical syncretism in contemporary compositions, and pedagogical approaches in the teaching and learning of music. As a music practitioner, Jue Ru also performs regularly on the yangqin and piano at professional concerts, International Arts Festivals staged locally and abroad, as well as in music outreach programmes.
Making Thinking Visible and Audible

The aim of this article is to deepen awareness of how we can develop students’ thinking and communication skills for understanding and learning of subject content. The article draws on the ‘making thinking visible’ research and resources (Ritchhart, Church, & Morrison, 2011, and Ritchhart, 2015), and explores both the ‘thinking’ and the ‘making visible’ aspects of this work. In addition, the article discusses ELIS’s research on effective communication for learning across the curriculum, and includes examples from teachers’ classroom-based inquiry into thinking and literacy in schools on the Whole School Approach to Effective Communication in English (WSA-EC) programme. In the article, I propose that student thinking needs to be both ‘visible’ and ‘audible’, and that ‘interthinking’ (Littleton & Mercer, 2013) is one way that students can learn together.

The article reviews thinking routines and considers how these can be used in different subject classrooms, and how well such routines fit with different syllabus frameworks and pedagogical models. Perspectives on the challenges of and opportunities for changing classroom culture in the Singapore context are presented here.

ABSTRACT

Thinking Skills, Communication, and Literacy

“Communicating effectively refers to the delivery of information and ideas coherently, in multimodal ways, for specific purposes, audiences, and contexts.” Standards and Benchmarks for Emerging 21st Century Competencies Singapore: Ministry of Education (2014)

Most researchers and educators today would accept that thinking requires language, and that language is the primary, if not only, resource needed to enable humans to think. Without language, the ability to develop cognitive competencies is severely compromised. Thus, when we speak of a thinking skill such as ‘hypothesising’, we should recognise at the same time that there are specific configurations of language that constitute the act of hypothesising.

For educational purposes and contexts, we typically expect students’ thinking to be expressed, articulated, or communicated to others in one of several modes: primarily, in the spoken or written modes of language, and through the visual or symbolic modes that are essential in science and mathematics. While it is possible to think but not share one’s thoughts with anyone, this is clearly not desirable in the context of classrooms. Teachers and students are embedded in the social context of the lesson, and communication is a critical part of this social event. If no communication occurs, to all intents and purposes, no lesson has taken place. Normally, therefore, there will be questions and responses, there will be reading and writing, and there will be visualisations and other representations of meaning occurring, all contributing to a discourse of the lesson. The topic or ‘content’ of this discourse will be the subject that is being taught and learned.

Communication Skills for Learning

Research undertaken by the English Language Institute of Singapore (ELIS) based on focus group discussions with curriculum developers and subject master teachers identified a set of common communication skills for learning from subject syllabuses (Doyle et al., 2015). These communication skills have been integrated into a simple framework for use with teachers (see Figure 1).
The key to developing students as effective communicators within their subject area resides in subject teachers developing students’ ability to explain, describe, discuss, present, argue, pose questions, articulate their reasoning, represent meaning in multiple modes, and use the subject language. What is important to understand about the language aspect here is that the way students explain phenomena or processes in, for example, Science, will differ from the way they do in History.

We can sum up the discussion so far by thinking of students’ competency in the communication skills described above as a form of literacy. By ‘literacy’, we mean the engaged thinking through reading, viewing, listening, speaking, representing, and writing which connects the prior knowledge of students and the teacher, texts (textbooks or other forms of text and media that the teacher or students introduce to the lesson), and real-world situations or phenomena, in order to build conceptual understanding.

A. Subject Literacy

Each discipline has its own typical ways of thinking which help identify it as that discipline and, therefore, will have related literacy practices that articulate that thinking through spoken, written, and visual modes. For instance, when reading a historical text (or ‘source’), we would want to know who the author is and when the text was written, whereas we would not be so concerned about the author or the date of the information when reading a scientific text, but we would be concerned about previous work in that specific field.

However, students may not have this literacy; they are likely to be novices in the ways of thinking of a discipline or subject and, therefore, are unaware of the conventional literacies associated with the subject that articulate and communicate ways of thinking. The notion of disciplinary literacy and, in the school context, the related notion of subject literacy, is important for teachers, because research (Shanahan & Shanahan, 2008; Mojé, 2008) has indicated that students stumble at the upper primary / lower secondary level as they make the transition from more generic literacy to the subject-specific literacies of Physics, Biology, Chemistry, History, Geography, and more advanced Mathematics. Subject literacy is the ability to use academic language appropriately, meaningfully, and precisely in a given subject area. It requires both proficiency in language and subject knowledge. Apart from conveying subject content through presentational modes of language use, subject teachers can facilitate understanding of content through interactional modes of language use in the classroom.

If we are to help students make their thinking visible, we need to consider what form this will take and, subsequently, what strategies teachers can use to help students acquire the literacies of their subjects. To clarify some of these points further, let’s take the example of reading. A common strategy for helping students with reading is that of ‘previewing’ a text. Previewing entails asking the reader to consider questions with which to start ‘getting into’ the text. Yet, these questions will not be generic across different subjects. For History, the questions are likely to include: “Who is the author?”, “When was this written?”, and “What is the context?”, whereas for Biology, the questions may include: “What is the phenomenon I am studying?”, “What do I hypothesise about this phenomenon?”, and “What do I hypothesise about this phenomenon?”.

Thus, disciplines and school subjects have characteristic communication skills used across different modes, and there are differences across these communication skills when found in mathematics, science, and the humanities.
It is suggested that the strategies teachers use with their students to support literacy would need to be tailored to these differences.

Development of Subject Literacy
In developing subject literacy, students need to progress from using imprecise language to refer to what is near, in sight, and familiar, to selecting more precise, subject-specific terms for referring to remote and abstract ideas, and, in so doing, communicate conceptual understanding. This requires them to gradually move from the everyday language of social interaction at home and with friends to the academic registers specific to the subjects they are studying (see Figure 2).

Gibbons (2009) discusses this move from informal language to the academic, subject-specific language required in learning different school subjects and highlights the need for the subject teacher to use scaffolding strategies to help students.

Teachers can also use more precise language when they are trying to prompt students’ thinking (Swartz et al., 2010). For example, when expecting students to use the skill of prediction, instead of using the question form: “What will happen next?” or “What do you think will happen next?”, they could ask: “What do you predict will happen next?”. Similarly, when using comparison in the lesson, rather than using less precise language such as: “Let’s look at these two pictures together to see how alike they are.,” they could say: “Let’s compare and contrast these two pictures.” In this way, the teachers are naming the thinking skill in the act of practising it, and thus making it more likely that students are aware that they are practising that thinking skill.

Ritchhart (2015) recognises this important aspect of developing thinking in the classroom through the language that teachers and students come to share. He identifies classroom ‘languages’ of thinking, community, identity, mindfulness, praise and feedback, and listening (Ritchhart, 2015, p. 68). As he notes, there is a vocabulary of thinking, which can be categorised into words defining processes, such as ‘reasoning’ and ‘justifying’; products, such as ‘hypothesis’ and ‘explanation’; and epistemic stances, such as ‘agreement’ and ‘doubt’. With conscious attempts by teachers to use this vocabulary, a shared language for thinking can become evident and explicit for students, thus making thinking ‘audible’.

Mathematical Literacy
In mathematics, the representation of meaning occurs across multiple modes, and teachers and students must continuously navigate shifts between the linguistic, graphic, and symbolic modes in order to develop mathematical reasoning and understanding (see Figure 3). Thus, making thinking visible in the Mathematics classroom is a matter of combining these three modes in various configurations. Mathematical literacy arises from being able to fluently shift between the three modes in order to present solutions to problems, explain those solutions, and justify the reasoning involved when challenged by peers during classroom discussion.

Figure 2: Moving Students from Informal Language to Subject-Specific Language (Gibbons, 2009)
Figure 3: Representation of Meaning in Multiple Modes in Mathematics
Presenting in Mathematics

Presenting is a mathematical communication skill. As stated in the Mathematics Syllabus, “to support the development of collaborative and communication skills, students must be given opportunities to work together on a problem and present their ideas using appropriate mathematical language and methods” (Curriculum Planning and Development Division, 2013, p. 20).

However, such presentations are not just talk alone, because students need to use mathematical language to present mathematical ideas and arguments precisely, concisely, and logically, with the use of multiple representations (symbols, tables, diagrams, graphs, and language).

Thus, presenting as a communication skill in mathematics is more complex and perhaps more challenging for students than in English Language classrooms. Research in mathematics classrooms in Singapore (Rahim, Hogan, & Chan, 2012) has demonstrated that presentation is a key component of communication. Students are tasked with presenting ideas or solutions, and possibly justifying these in response to questions or challenges from other students. They will be solving the problem on the whiteboard, using the symbolic language, participating in group presentations and discussions, and explaining their solutions. They may also be expected to write up these mathematical communicative experiences in a journal.

Literacy in Science

In a manner similar to mathematics, literacy in science classrooms involves shifting between spoken and written language modes, and the visual mode (see Figure 4). Other communication skills involved will include describing and explaining phenomena, using the appropriate subject language (of Physics, Chemistry, or Biology), and questioning and discussing interpretations and findings.

Three Dimensions of Science Communication

![Dimensions of Science Communication Diagram](image)

Figure 4: Dimensions of Literacy in Science
To develop students’ science literacy, Tang, Ho, & Putra (2016) illustrated mapping subject literacy over instructional models (see Figure 5).

**Intervention: Developing Students’ Science Literacy**

The stages of the ‘5E’ instructional model (Bybee, 1997) – Engage, Explore, Explain, Elaborate, Evaluate – all provide opportunities for students to communicate in different modes and with different interactional patterns of monologue, dialogue, and discussion. For example, at the ‘Explain’ stage, if given sufficient time, students can present their initial understanding of phenomena and discuss these with other students in a teacher-facilitated whole-class discussion. Such discussions, in turn, afford teachers the time to monitor conceptual understanding and feed in the more precise language of science where appropriate.

### B. The Role of Talk in Learning

What is the value of talk for students when learning a subject? Fisher, Frey, & Rothenberg (2008) state, “If students aren’t using the words, they aren’t developing academic discourse”. In their study, they found that while students appear to be interacting with their teachers in class, a closer look revealed that all the subject language was spoken by the teacher, while the students were using everyday language or imprecise ways of referring to concepts and processes in the subject lessons. Research on classroom interaction has established that quality of talk is critical for student learning. Teachers can model subject communication skills and scaffold students’ development of these skills though talk. Dialogic talk (Alexander, 2008) builds students’ thinking and helps them accumulate understanding. Opportunities for extended student talk are also opportunities for teachers to practise assessment for learning. In other words, teachers who ‘open up talk for learning’ in their classrooms provide opportunities for students to articulate their thinking, challenge the articulated thinking of others, and, with the teacher’s facilitation, construct and consolidate understanding.

**Classroom Talk**

“If we improve the quality of classroom talk, we improve the quality of learning.” (Mercer, N. 2014)

Here are some questions for teachers to stop and reflect on:

1. When do your students talk, and why?
2. How much do they usually say?
3. How does, or could, student talk impact learning in the classroom?
4. What do you believe about the role of talk for learning?

Some educational experts believe, “if we improve the quality of classroom talk, we improve the quality of learning” (Mercer, 2014). They believe that language is essentially a tool for doing thinking. In addition, they conceive of it as a resource for making meaning that...
IRE discourse patterns can lead to ‘recitation talk’, where the teacher appears to be more concerned with completing a script and ‘covering the content’ than exploring students’ understanding and building a learning community in the classroom. A typical IRE exchange from recitation talk is shown below:

**Teacher:** (I) What’s the name of this part?

**Student:** (R) The stamen.

**Teacher:** (E) Good!

Lessons may be built up from many of these IRE exchanges, but they often do not ‘add up’. The exchanges are frequently disconnected from each other, with the result that there is a low coherence in the discourse. Thus, it can become difficult to ‘follow’ the script. This may not be apparent to the teacher who already knows the script and knows the answers to the questions that he or she asks. For students trying to make sense of the lesson and understand new concepts and relationships, this can be challenging.

However, by encouraging teachers to use a ‘Follow-up’ move instead of an ‘Evaluation’ move, we can significantly alter the nature of the discourse. Instead of saying, “Good!”, if the teacher were to say, “Student B, do you agree with that answer?”, thus using an alternative talk move and withholding evaluation, he or she can begin to build a more dialogic discourse (Alexander, 2008) that ‘opens up the talk’ and allows more students to articulate their thinking, challenge others’ thinking, and listen more critically to the responses of other students.

Unfortunately, research evidence suggests that improving the quality of classroom talk is hard to do, since many teachers quickly fall into the default discourse pattern of Initiation–Response–Evaluation, or IRE (Cazden, 2001), which often leads to limited student response to questions that are mainly of the factual recall type. Doyle & Hong (2009), for example, found that across some 60 lessons from Primary 5 (P5) and Secondary 3 (S3) classes in English Language, Social Studies, Science, and Mathematics, teacher talk time varied between 70% and 85%. Similarly, of the number of words uttered in lessons, 80% were from the teacher and 20% from students. Mean utterance length for students’ responses was between 2 to 3 words (see Figure 6). Similar findings have been reported in other educational settings.
At this point, it might be useful to look back to your answers to the questions at the start of this section and reflect on your own use of classroom talk.

**Teacher Talk Repertoire**

Walsh & Sattes (2015) provide a useful overview of the types of talk that teachers and students can engage in when focusing on building content knowledge, highlighting the notion of selecting from a repertoire of types of discursive talk and related learning configurations (see Figure 7).

![Figure 7: Repertoire for Teacher and Student Talk in Classrooms](adapted from Walsh & Sattes, 2015)

Generally, in the classroom, we have the possibility of dialogue and interaction for deepening understanding and interthinking about subject content. Unfortunately, much research conducted in Singapore classrooms, and in classrooms elsewhere, shows that teachers and students often do not achieve this, due to a disproportionate amount of monologic talk by teachers, or else a form of question-answer routine, referred to by some as the ‘recitation script’ (REF), that seems more ritualistic than exploratory. What is lacking, according to Mercer & Littleton (2007), is evidence of a substantial amount of dialogic discourse, where teachers and students engage in co-construction of knowledge and interaction.

Teacher-guided whole-class interaction, when facilitated effectively, can lead to productive academic discussion, when students have the chance to learn how to talk within the subject discipline and to acquire subject-specific language. From such productive academic discussions involving the whole class, students can move to small-group discussions set up by the teacher, where there is a focus on exploring activities, solving problems, or rehearsing procedures. Eventually, over time, students may be able to participate in student-initiated interactions without a teacher’s guidance.

The term ‘productive academic discussion’ refers to a set of focus areas and talk moves that teachers can work on, as shown in Table 1.
C. Using Talk Moves in the Classrooms

One of the main aims of ELIS’s work with schools has been to explore how to ‘open up’ classroom talk so that students have opportunities to participate in making their thinking audible in subject classrooms. To do this, it is necessary to revisit the ways in which talk is used in different types of teaching and learning activities, and to recognise that teachers may need to loosen their control of classroom interaction in order for more students to participate more effectively in different types of spoken interaction.

This revisiting is a process of teacher inquiry in which participants on ELIS courses practise the talk moves related to focus areas that they want to work with, and then apply these in their classrooms. They embed a productive academic discussion into a lesson on a topic from their subject syllabus. After transcribing short audio and video recordings of the discussions, they examine their own talk and consider alternative ways of phrasing their questions and their responses to students’ answers. In so doing, they evaluate the effectiveness of their talk by considering what students’ responses reveal about the students’ learning.

CONCLUSION

Given sufficient guidance, teachers can integrate subject-specific literacy practices into their existing pedagogical routines and, in so doing, enhance their students’ competency in the communication skills they need to develop. Furthermore, with a clearer understanding of classroom talk as comprising a repertoire that they can draw on to support learning, and the use of ‘tools’ such as talk moves for facilitating productive academic discussions in class, teachers can help students to make thinking audible.

REFERENCES


ABOUT THE CONTRIBUTOR

Dr Paul Doyle has been supporting teachers in Singapore for over 30 years. His current interests are in developing subject literacy resources for teachers and conducting research into the efficacy of literacy support strategies in mathematics, science, and the humanities. Since 2012, he has designed several professional learning courses on subject literacy and effective communication for learning, and conducted many sessions of these with school key personnel and senior staff.
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