Knowledge Building

STARTER'S RESOURCE KIT

Welcome to Knowledge Building!

We are pleased to welcome you to our KB Singapore community. This resource kit provides you with information to start your KB journey.

KB is an approach of learning through ***collective idea improvement*** among students. This approach treats all ideas as improvable and develops in our students an appreciation for the hard work needed to improve a promising idea.

A KB classroom provides the collaborative learning environment needed for students to ***explore authentic problems related to the world around them.*** These ideas and problems can be shaped by teachers in relation to key concepts in the curriculum. ***Students read and build on each other's ideas, and seek information about these problems to improve their explanations to them. While improving their ideas and explanation, students naturally deepen their understanding of the topics surrounding the problems***.

KB approach leverages the different perspectives and expertise of students to bring about deep learning for all. The approach is only complete when there is ***articulation of ideas and explanations through concrete artefacts***. Thus an online space, the ***Knowledge Forum***, is needed for knowledge building to be meaningful and effective in class. For example, students would need to write "rise-above" notes to represent their "best" explanations synthesized from the different ideas in the discussion. This is also the only way in which teacher can understand the trajectory of students' ideas, and for teachers to be able to release the ownership and agency of learning to students.

Your students' minds will be challenged and stretched as they embark on knowledge building. It is an exciting and meaningful journey for you and your students. However, we acknowledge that it is not an easy task to design and facilitate a KB classroom. We can't do it on our own; we need the community to learn, grow, and celebrate together.

We invite you to explore KB with us, enjoy it to the fullest, and see the benefits in your students' learning. We look forward to working with you to ensure a sustainable future for our community.

We would like to thank all the schools in the KB community, who have shared with us information, data, and insights, over the years. Some of the pictures shown in this kit have been sourced from these schools: Teck Whye Secondary School, St Hilda's Primary School, Endeavour Primary School, and Macpherson Secondary School.

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Section 1. What is KB?

These are the 12 Knowledge Building Principles that define KB: they are a set of workable principles that guide teachers' decision in class (routines, activities, rules of engagement) and serves as the basis for their actions and behavior in class. These principles also guide teachers to reflect on their practice.

Community Knowledge

Constructive Use of Sources

Democratising Knowledge

Epistemic Agency

Idea Diversity

Improvable Ideas

Knowledge Building Discourse

Pervasive Knowledge Building

Real Ideas, Authentic Problems

Rise-Above

Systematic Knowledge Advancement

Transformative Assessment

Over the next three pages you will find an elaboration of the 6 most useful and relevant KB principles: *Real Ideas, Authentic Problems; Idea Diversity; Improvable Ideas; Rise-Above; Constructive Use of Sources;* and *Knowledge Building Discourse*.

For a detailed description of all 12 KB principles, please visit our website http://www.kbsingapore.org

From Principles to Practice

Here we describe the 6 most useful and relevant KB principles in day-to-day classrooms. We also provide some questions you can ask yourself in order to translate these principles into action.

1. Real Ideas, Authentic Problems 

What it really means	*For teachers to reflect on*	*For students to understand*
Students explore problems about the world around them; these are problems initiated by themselves and that they really care about – usually very different from textbook problems. Students produce concrete ideas during the inquiry process, not abstract concepts that is talked about and forgotten in subsequent lessons.	• Are the problems I introduce in class generally initiated by students or by me? • Are the problems I introduce in class those that students really care about and/or find interesting? Are they any different from textbook problems? • Do I get students to write down their ideas and think about their ideas? • Am I modelling the thinking/kb scaffold in class? • How often do I use these phrases ("can you say more about your idea?", "I never thought of that, what do the class think?")	When we examine the environment around us, we may discover problems that need to be resolved. Let's examine real world problems and propose ways to resolve them.

2. Idea Diversity 

What it really means	*For teachers to reflect on*	*For students to understand*
Students read about different ideas about the topic, including contradictory ideas. Students feel safe taking risks in class – sharing half-baked ideas, and giving and receiving criticism to and from peers	• Do I get students to examine different ideas about a topic? • Do I provide time in class to discuss about naive ideas or misconception? Or do I just correct them. • Do I make students feel safe in taking risks in class by the way I model and respond to their ideas? • Do I allow ideas to be identified based on how interesting they are to the inquiry problem and not just how much curriculum it can cover?	Exploring many ideas and different types of ideas is important for learning. When we examine many different ideas, we are better able to create new and more refined ideas.

3. Improvable Ideas

What it really means	*For teachers to reflect on*	*For students to understand*
The classroom environment (both online & offline) supports development of ideas into new and more refined ones. All ideas are treated as improvable, and students work continuously to improve the quality of their ideas. Ideas are identified based on how promising they are to the inquiry, not just on how accurate they are at that point of time.	• Do I provide time for students to synthesize and refine their ideas? • Do I encourage students to improve the quality of their ideas? Or do I just correct them? • Do I spend time to track the way students' ideas are improved?	We believe that ideas can be improved. So it is alright for our friends to share ideas that may be "half-baked", provided we work to improve them. We must not form an opinion about the quality of an idea or disregard it before we (i) Have enough understanding of it (ii) Put in some effort to see how it may be improved.

4. Rise-above

What it really means	*For teachers to reflect on*	*For students to understand*
Students work towards higher-level formulations of problems. Students work with different ideas, achieve new synthesis of ideas, and acquire deep understanding of the topics.	• Do I allow students to work with diverse ideas and achieve new understanding of the topics? • Do I get students to read, analyse, and interpret information about the topic based on each other's notes and ideas?	**Rise above what we know now:** We aim to learn more. Thus, we are prepared to (i) Examine many different ideas and points of view. (ii) Work with messiness so as to move towards new and better organised ideas. (iii) Reason about ideas that we don't understand and try not to ignore or simplify the ideas.

5. Constructive use of good information sources

What it really means	*For teachers to reflect on*	*For students to understand*
To know a discipline is to know the authoritative sources that mark the current state of knowledge and its	• Do I allow students to search and share information in different formats, e.g., online resources, magazines, other books, etc.?	**Use sources of information wisely:** There are different sources of information we can draw on to clarify our understanding or support our point of view.

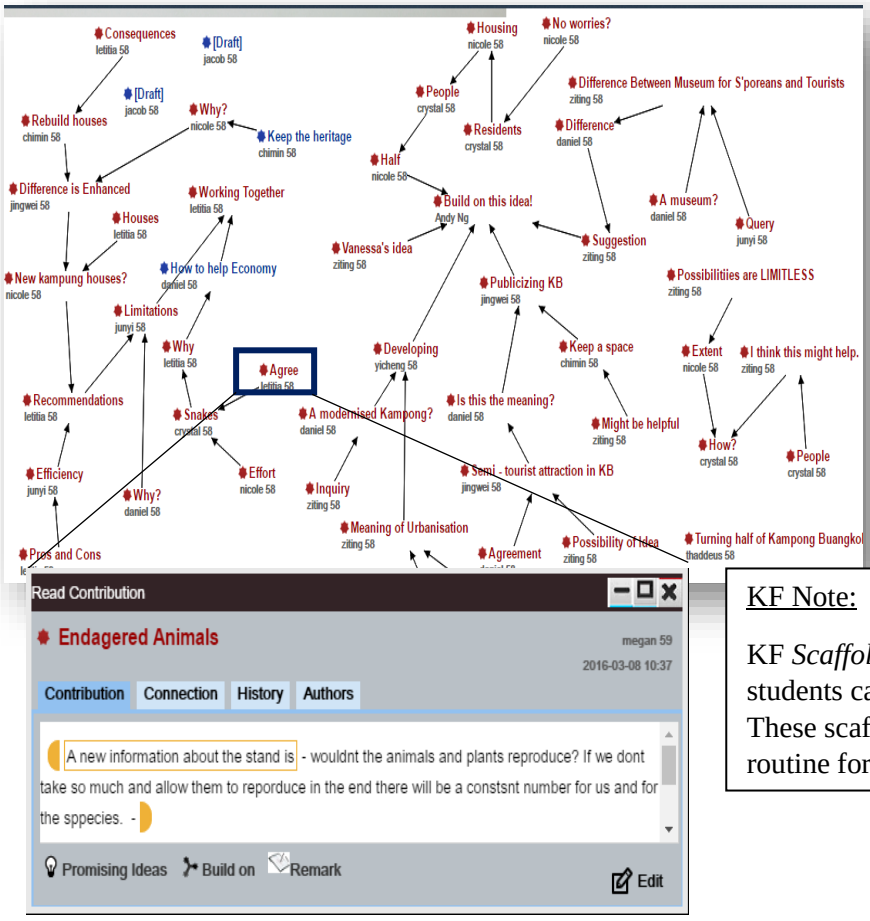
frontiers. Knowledge innovation requires respect and understanding of these sources, combined with a critical stance toward them. Students search for, analyse, and interpret information in online resources, text-books, and other sources of information presented to them.	• Do I get students to reference and quote their sources?	But we must be critical users of these sources of information. **For example**, we may check whether the source ▪ Is current (or outdated). ▪ Provides reliable information (that is backed by evidence) rather than make claims that are biased and not supported by evidence. ▪ Provides an objective point of view (present different points of views as well as provide sound explanations for own point of view).

6. Knowledge Building Discourse

What it really means	*For teachers to reflect on*	*For students to understand*
Students should be doing more than simply sharing information. Students' ideas, questions, and knowledge should be refined and transformed through the discussion.	• Do I conduct discussions where students do more than share information? • Do I conduct discussions where students are provided opportunities to refine their ideas and questions? • Am I always the main person responding to students during discussions? • Do I allow some of my classroom discussions to end with more questions for further investigation? • Do I consciously stop myself from giving the final or best answers in class?	Consolidating the 4 other sets of rules defined above.

Knowledge Forum

Knowledge Forum (KF) is a collaborative online platform workspace designed for students to share information, questions, and ideas, and build networks of new ideas collaboratively. Every student can read and share their ideas shared to the entire class. KF captured and archived ideas as written notes, making students' thinking visible and making it possible for teachers to trace idea development.



KF consists of *Views*, each view is a space on KF that can be used to organize students' *notes*.

KF displays the connections between ideas (that occur in the form of *build-ons*), and allows for ideas to be archived and improved.

KF Note:

KF *Scaffolds* are sentence starters that students can used to start their notes. These scaffolds serve as thinking routine for knowledge building.

Table 1 demonstrates how KF supports the 6 Knowledge Building principles detailed previously.

Table 1: How KF supports the KB principles

	KB Principle	How KF supports the principle
1.	Real Ideas, Authentic Problems	KF creates a culture for creative work with ideas. Every idea is captured and archived, and Notes and Views serve as direct reflections of the ideas of students.
2.	Idea Diversity	- KF supports the interaction of ideas and enables different ideas to be shared and archived. - KF facilitates the linking of different ideas together, which

		promotes interaction and idea diversity.
3.	Improvable Ideas	- KF supports recursion in all aspects of its design – there are always opportunities for continual improvement, revision, and refinement. - Students are able to refine and advance understandings. - KF enables you to trace idea development and see how consensuses are reached - Improving ideas encourage students to identify shared problems and gaps in understanding.
4.	Rise-above	- KF supports emergent rather than fixed goals. - KF supports the unlimited embedding of ideas in students' attempts to improve their understandings. - KF facilitates the synthesizing of different ideas together (the build-on feature in KF), which leads to knowledge advancement.
5.	Constructive Use of Sources	KF enables students to use information sources as data for their own knowledge building and idea-improvement processes.
6.	Knowledge Building Discourse	- KF supports texts which are rich in notes, and views that are timely and emerging according to the inquiry happening in the class. - KF enables the tracking of Standards and benchmarks (literacy, 21st CC skills, and productivity), which are objects of discourse and by-products of KF work.

Although KB can theoretically be done without the use of KF or any knowledge building technology, it is highly recommended that KF is used, as it provides affordances that a normal "offline" classroom environment lacks (Table 1).

There are also analytical tools on KF that enable teachers to track the progress of the class as a whole entity, as well as of each individual student. For more information on KF, please visit our website http://www.kbsingapore.org/

The next part, 'Knowledge Building Scaffolds', will demonstrate how KF can be adapted to the needs of the classroom through means of customising new sets of scaffolds.

Knowledge Building Scaffolds

KF provides 6 theory-building scaffolds to help shape to Knowledge Building discussion and deep learning. The scaffolds are embedded in notes to help students in building knowledge.

Table 2: The KB trajectory with regards to use of the KB scaffolds

KB trajectory	KB Scaffold	KF principle(s) supporting the scaffold
Identify the problem of understanding	I need to understand	Real Ideas, Authentic Problems
Formulate own problems	My theory	Idea Diversity; Improvable Ideas
Collect facts (experiments, resources, text book)	New Information	Constructive Use of Sources: Collecting facts through experiments, resources and text books
Fact #1 + Fact #2 + Fact #3 — Theory #1(possibly naïve or raw)	This theory doesn't explain	Idea Diversity; Improvable Ideas**:** Identifying gaps in hypotheses of explanation
Fact #4 - and Theory #1 doesn't explain Fact #4	A better theory	Rise-above
Improve the theory ... Theory #2	Putting our knowledge together	

**These processes shown in Table 2 are not to be considered linearly.*

The 6 theory-building scaffolds provided in KF:

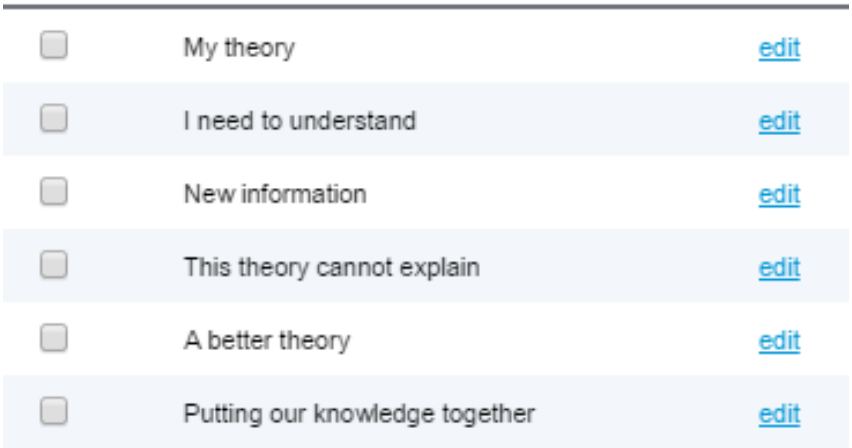


Figure 1. The 6 scaffolds provided by KF.

The 6 KF scaffolds can be modified for different subject but we advised that the trajectory is maintained. Following are three examples of teachers' effort in redesigning the scaffolds for their class.

Example 1: Customised scaffold (adapted from http://

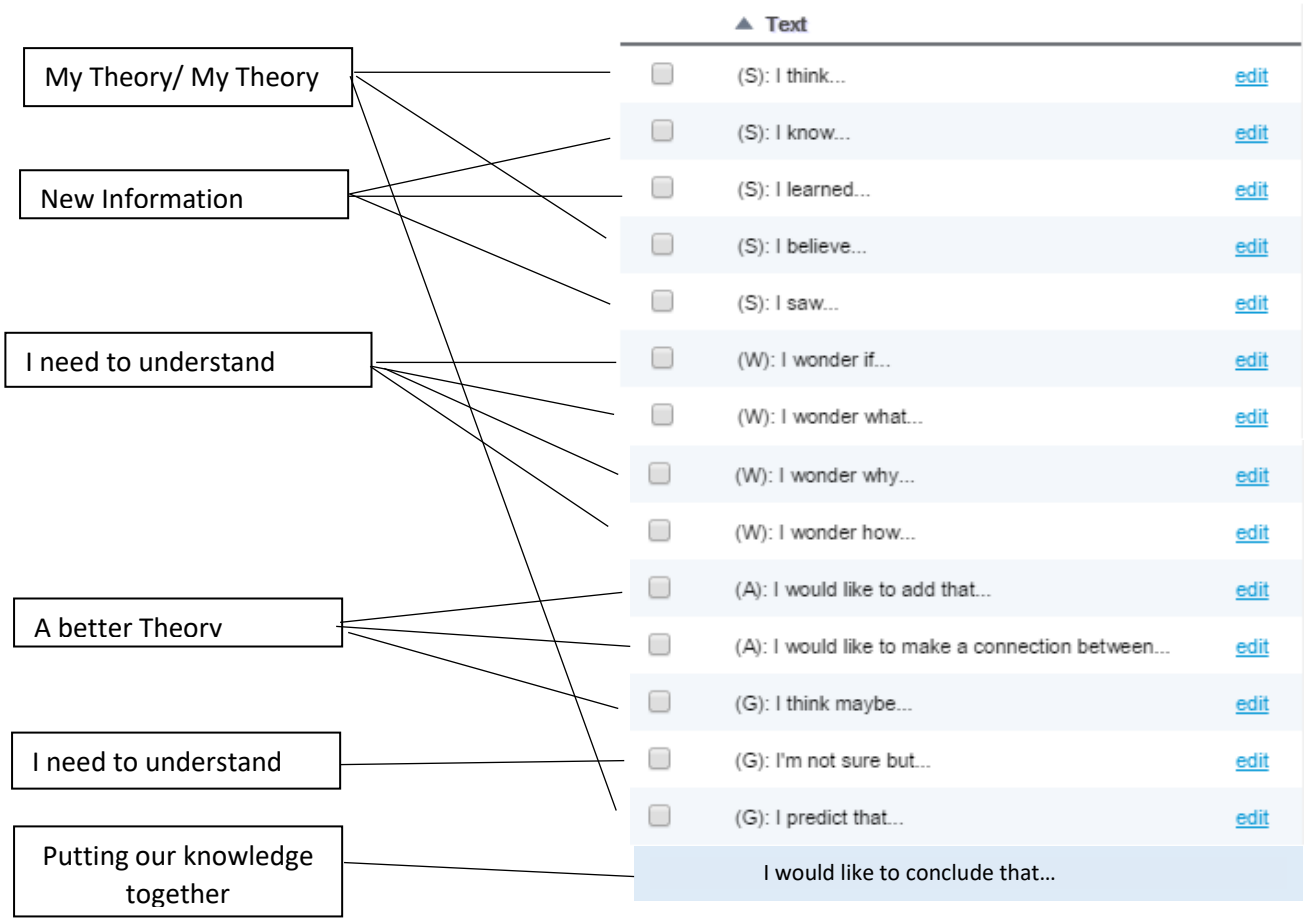


Figure 2. A customised scaffold (1st example).

Example 2: Customised scaffold (for specific subject, in this case, social studies)

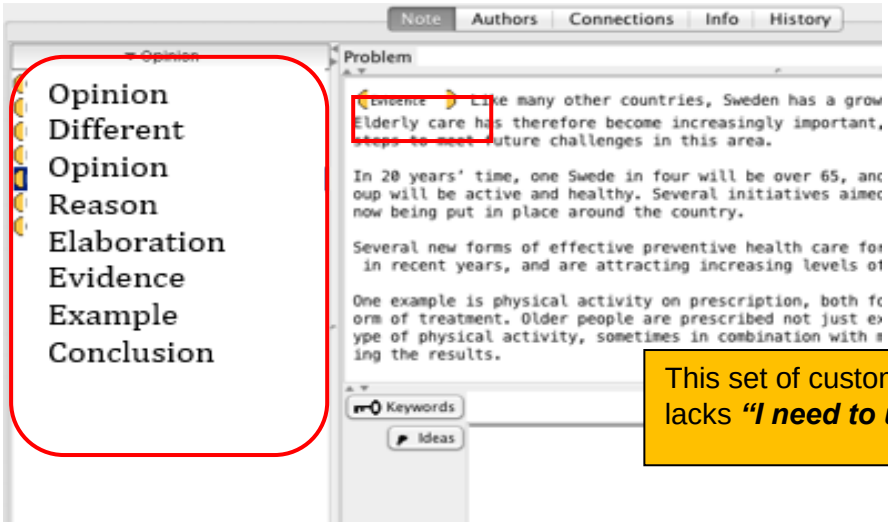


Figure 3. A customised scaffold (2nd example).

Example 3: Customised scaffold (for specific content)

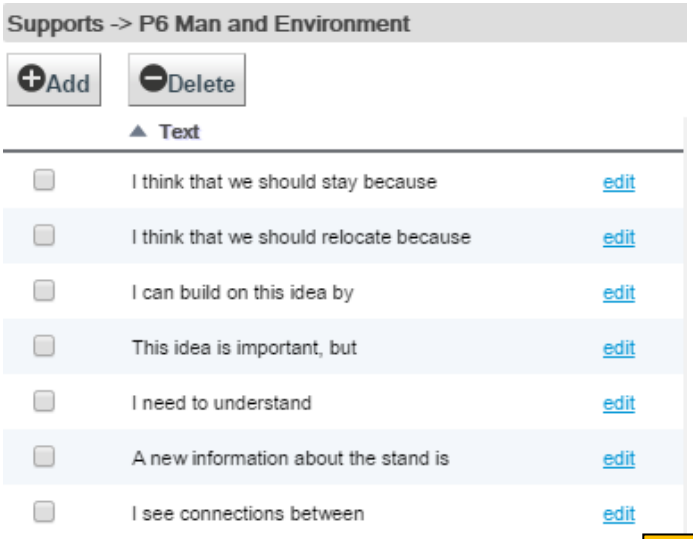


Figure 4. A customised scaffold (3rd example).

This set of customised scaffold lacks ***"Putting our knowledge together"***

Section 2. How to Conduct a KB lesson

The KB Pedagogical Framework

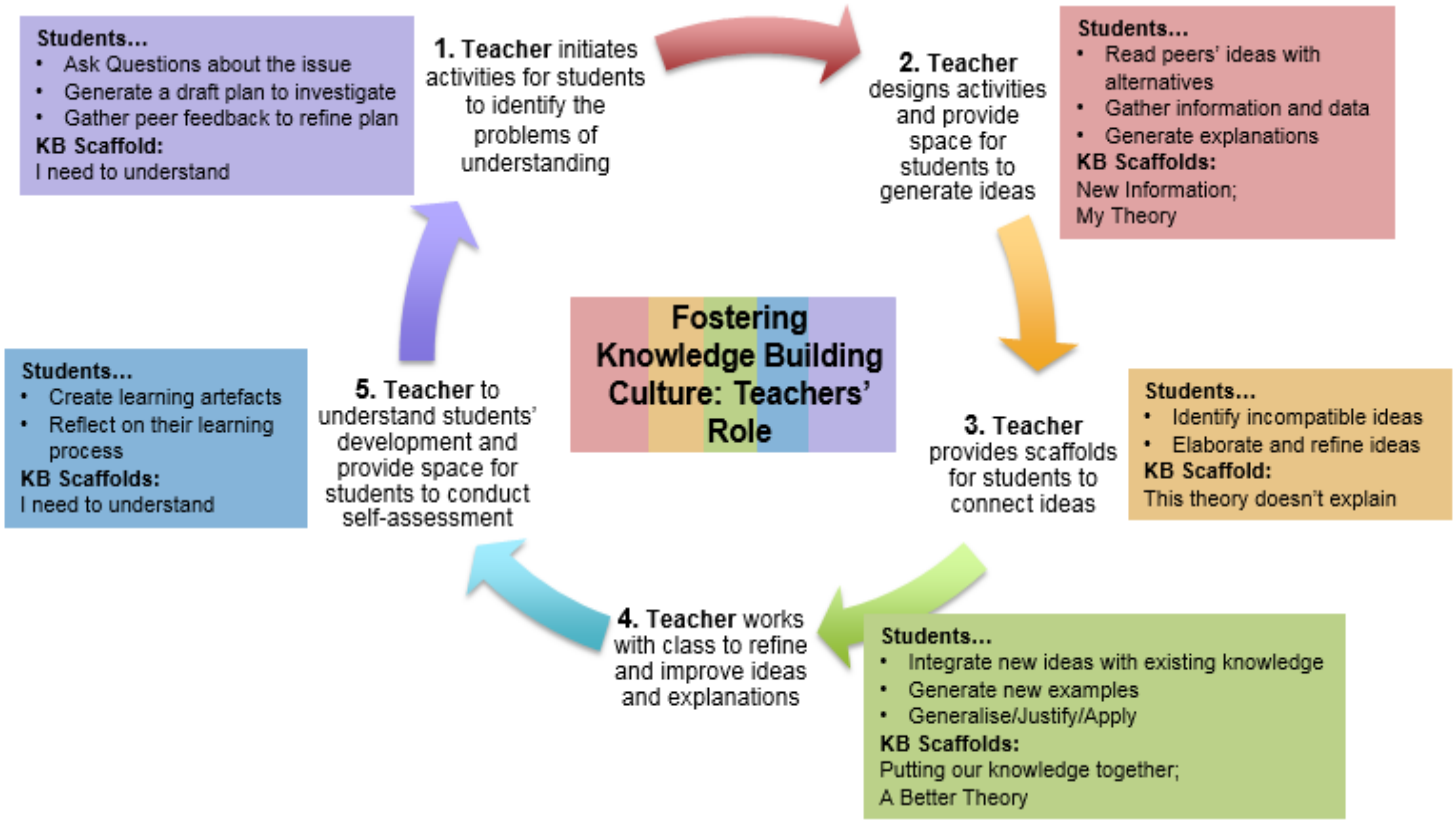


Figure 5. The KB pedagogical framework.

Figure 5 shown above is the KB pedagogical framework that guides teachers' planning and design of lessons. The 5 stages constitute one full cycle of KB lessons.

In this section, we will describe in-depth what goes on at each of the 5 stages of the pedagogical framework. Examples and snapshots of actual students' databases in KF will be provided, so that you get a clear and complete understanding of what encompasses a cycle of KB lessons.

1. Fostering Knowledge Building Culture: Rules of Engagement

It is important to foster a knowledge building culture in students at the start of your lessons. You must view your classroom as not just a group of individual students, but as a collective entity where students work collaboratively to advance communal knowledge.

To foster a knowledge building culture in your class, you can start by setting 'Rules of Engagement' that all students must adhere to throughout the lessons. One example of an enculturation strategy is to use the Wright Brothers' story (refer to Appendix A) as a role model for students to follow. A second example is to explicitly set out rules - example rules are shown below:

Rule #1: Everyone's idea is important

What we must do:

1. Respect your classmates and their ideas by being polite – there should be no vulgarities or name calling.
2. Do not correct your classmate's spelling or writing on KF – you can go to your classmate directly for that. You can, however, ask your classmate to clarify his or her ideas written on KF.
3. Give constructive comments to your classmates to help them improve on their work. Comments should be specific so that your classmates know exactly what you are referring to.

Rule #2: We need to work with different ideas to learn better

What we must do:

1. Read all posts on KF before you post the problem which you have identified, so that you do not post a problem that your classmates have already identified.
2. There is never a bad idea, just a different idea. If your classmate has posted something that you don't agree with, you can ask for further explanations.
3. To minimise confusion, begin the title of your post with a scaffold, and write down your problem/question in the problem space.
4. Reference your notes and provide attachments whenever possible.

Rule # 3: No single person can learn more then what the whole class can learn together

What we must do:

1. In every KF lesson, you have to read and comment on your classmates' posts, as well as post your own ideas/questions and respond to your classmates' comments on your posts.
2. Share what you know and what you have learnt in your class's Views and Notes.
3. Type one idea per posting. For example, if clarifications of two points are needed, then these should be done in two postings.

1. Getting the real problem to kick-start Knowledge Building: Trigger Activities

After you have set out the rules of engagement for students, it is time to begin your lesson. You can start with a "trigger" activity. A "trigger" activity could be a whole-class discussion or an experiment set up over a period of time for students to observe and collect real data. The aim of "trigger" activities is to set the learning in motion and sustain the knowledge building pursuit. The "trigger" serves to stimulate and focus students' interest on the theme or topic in question. At this stage, students are encouraged to generate and share ideas.

At this stage, **Students** should be:

- Asking questions about the issue
- Generating draft plans to investigate
- Gathering peer feedback to refine plan

KB Scaffold: *I need to understand*

Strategies for planning your KB approach to inquiry:

a) Do a quick scan on discussion topics or research that are related to the inquiry topic.
b) Map out the key concepts of the topic and try to draw connections to the inquiry questions, if possible.
c) Brainstorm all possible directions the inquiry questions can go; what are the possible questions, ideas (even misconceptions) from students
d) Brainstorm possible resources that might be useful.

Over the next 2 pages, we will provide 2 examples of trigger activities that have been done by teachers. For more examples of trigger activities, you can refer to our website www.kbsingapore.org.

Example 1: Theme – Cells and DNA (Secondary Biology)

A teacher got her students to conduct an experiment involving extracting DNA from crushed strawberries. Students smashed strawberries, added extraction liquid (made of detergent, salt, and water), filtered the mixture, and added rubbing alcohol to the filtered strawberry liquid. The resulting white precipitate/reside (i.e. strawberry DNA) that appeared on top of the strawberry mixture (Fig. 6) triggered students' curiosity.

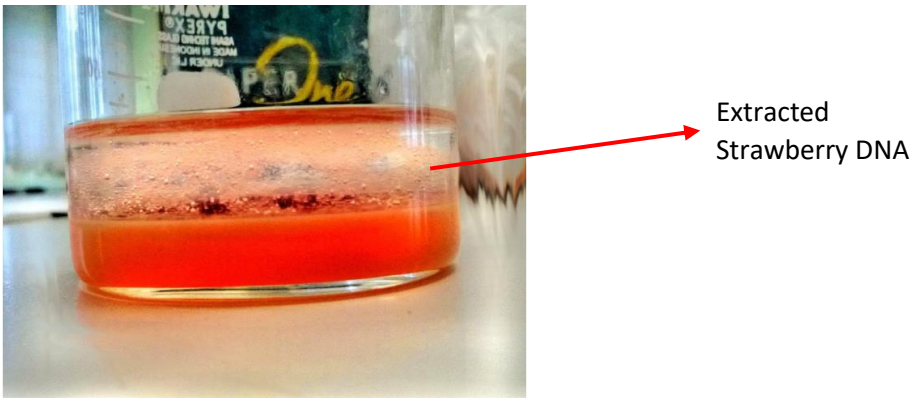


Figure 6. Result of a strawberry DNA experiment that students conducted.

The following lesson, the teacher initiated and facilitated discussion on KF with her class. Students posted plenty of notes about the phenomenon/ experiment (questions, ideas, information) based on the knowledge or experience that they had (Fig. 7). The teacher conducted whole-class discussions to elicit students' ideas and consolidate a few questions that students were really interested to find out. These questions were built on and improved over subsequent lessons, and students' discussions on KF revolved around the main concept of cells.

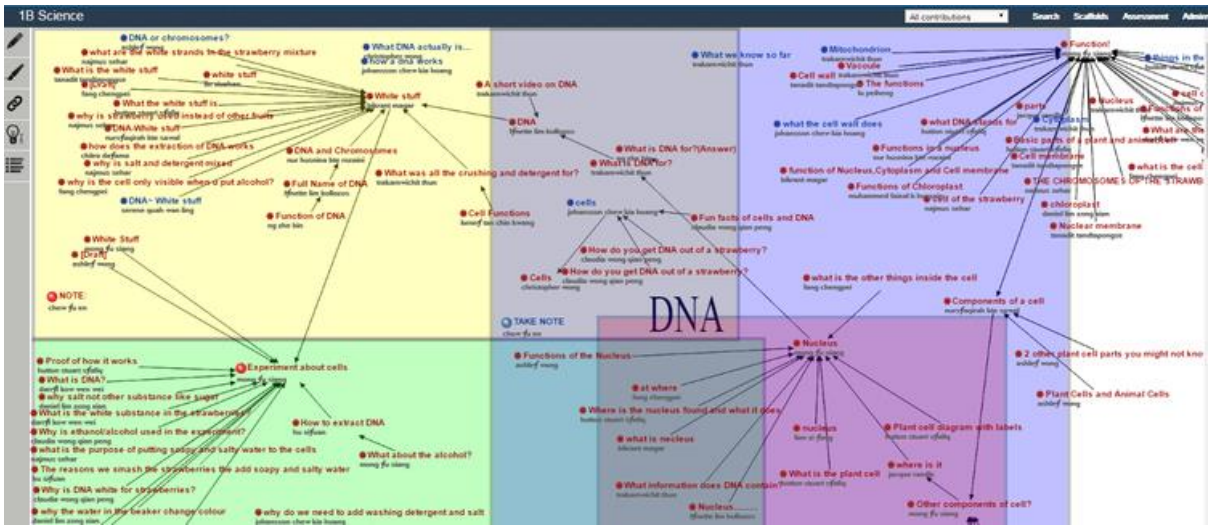


Figure 7. Students' notes on KF about the strawberry experiment.

Example 2: Topic – Magnets (Primary Science)

A teacher's trigger activity on the topic of magnets was to have her students conduct an experiment involving a freely hanging magnet and another magnet on hand. Prior to the lesson, students had observed a freely hanging magnet and the direction in which the magnet came to rest in. Students consequently conducted the experiment, with the teacher prompting them to feel how the magnets react when put together (Fig. 8).

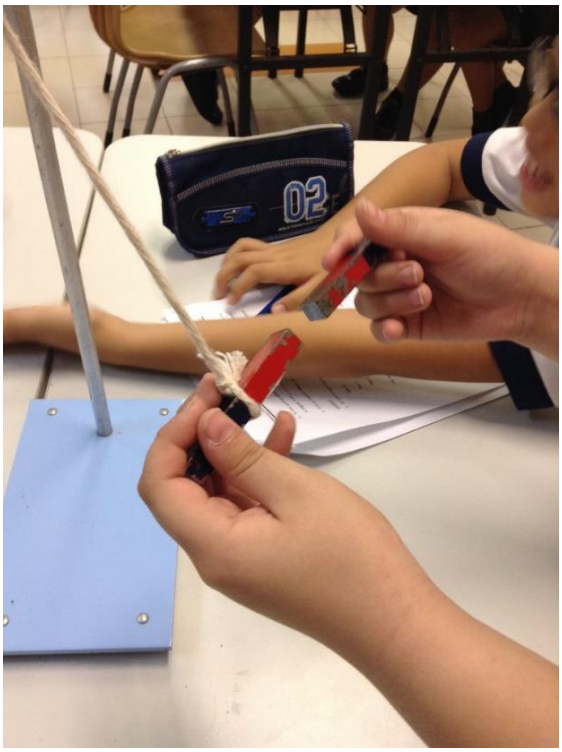


Figure 8. Students conducting an experiment on magnets.

Afterwards, students verbally discussed the experiment in class before the teacher got them to go online in KF to post their observations, thoughts, and ideas. Students generated many questions and ideas they had about the experiment (Fig. 9).

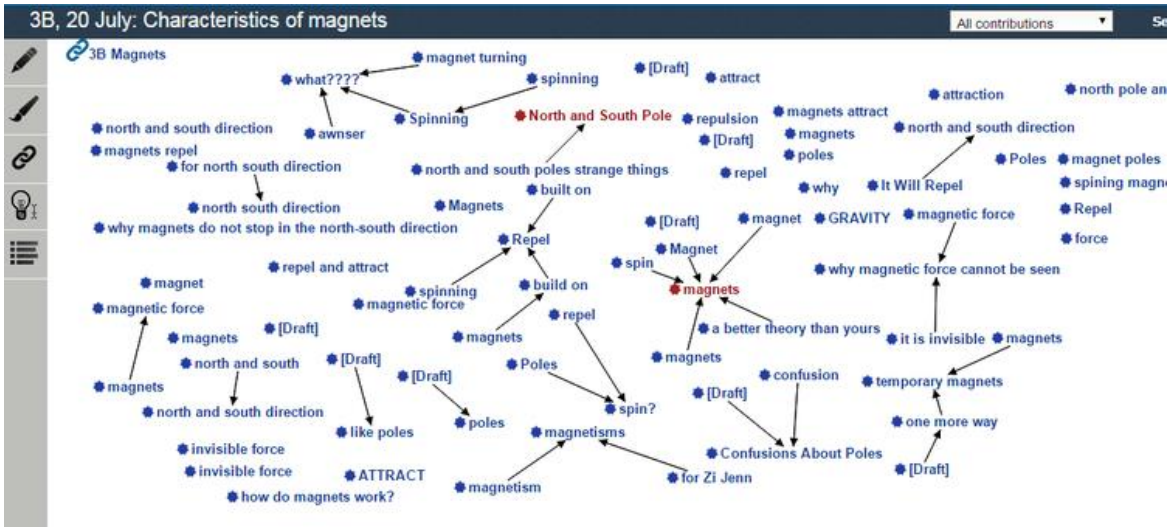


Figure 9. Students' notes on KF about the magnets experiment.

2. Idea Generation

After you have piqued students' curiosity and interest in the topic at hand, it is time for them to start generating ideas. Any activities you design should help students to identify the inquiry question(s) that makes most sense to them.

At this stage, **Students** should be:

- Reading peers' ideas with alternatives
- Gathering information and data
- Generating explanations

KB scaffolds: *My theory; New information*

Things to think about before you get going:

a) Suspend judgement

- Try not to react to 'right ideas', but instead acknowledge all ideas
- Try not to correct spelling mistakes in the initial stage so that students will not feel discouraged

b) If you want to get students to record their ideas on pen-and paper, some example strategies to use are idea cards (refer to Appendix B) or students' ideas worksheet (refer to exercise 1 & 2 in Appendix C).

Strategies for stimulating idea generation:

1. Allow students to post intuitive questions and ideas on KF and encourage reading of notes (notes on KF turn red after being read).
2. Provide time for students to build-on to one another's note.
3. At this stage, it is important to consciously help the class to focus more on the inquiry process and questions than on syllabus coverage.
4. Explain to students the use of different scaffolds and "what makes a good note".
5. Highlight interesting questions and ideas that surface on KF in subsequent lessons.
6. If students are posting on KF, ensure that they use the scaffolds 'I need to understand', 'My theory', and 'New Information' (you need to provide these scaffolds for them).

A snapshot of the idea generation process is shown in Figure 10 on the next page.

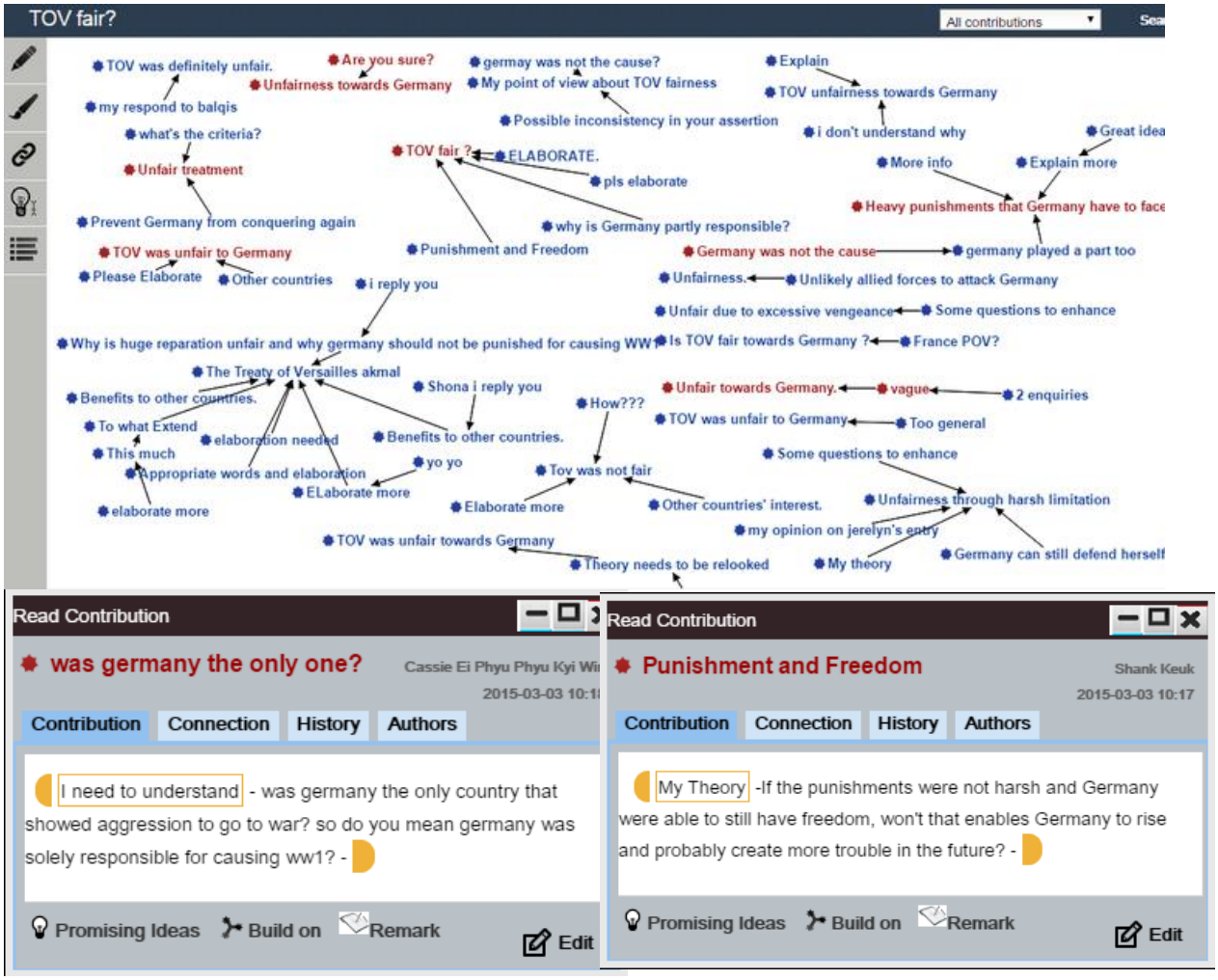


Figure 10. A snapshot of students' notes on KF during the idea generation process, and two examples of student-generated questions

Some considerations for the design of activities:

- Connect the topic personally to students' lives (e.g., a teacher created a simulation of the impact of smoking on lungs because many of her students' parents were smokers. She did this experiment with a burning cigarette and a bottle of cotton wool).
- Create opportunities for fieldtrips /out-of-classroom experienced, or virtual environments/ virtual resources.
- Provide introductory hands-on activity.
- Pay special attention to questions, suggestions or observations that arise.

3. Idea Connection

After you have designed and carried out your planned activities, you will now have to guide students into the process of connecting the ideas they generated. At this point of time, students should have already come up with a pool of questions, ideas, and information, based on your trigger activities and subsequent lessons. These can be in the form of online postings on KF, or on idea cards (refer to Appendix B).

Scaffolding is a key feature of KF and the main technique used in knowledge building work on KF (Scardamalia, 2004). Scaffolds in KF are designed to guide students towards cognitive processes that will help them acquire new meaning and improve their understanding. Students use scaffolds to connect ideas and visually construct a web of knowledge based on their and their classmates' postings. The basic set of scaffolds in KF are:

- My theory
- I need to understand
- New information
- This theory cannot explain
- A better theory
- Putting our knowledge together

Additionally, it is important to note that scaffolds can also be in the form of questions that you pose to students during class discussions. Scaffolds are simply prompts for students to connect ideas. Alternatively, you can likewise get students to connect their ideas on pen-and paper, e.g., using the students' ideas worksheet (exercise 3 in Appendix C).

At this stage, **Students** should be:
- Identifying incompatible ideas
- Elaborating and refining ideas

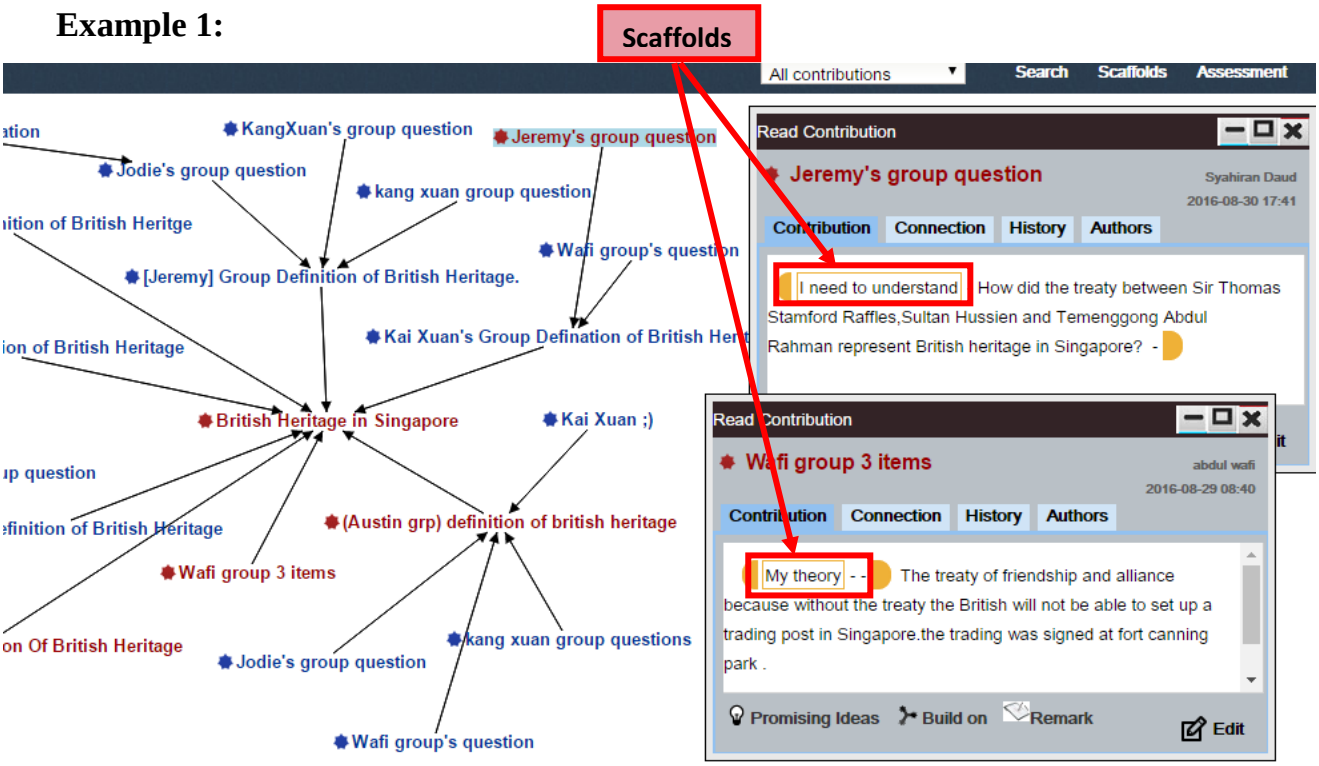
KB scaffold: *This theory does not explain*

Strategies for facilitating idea connection:

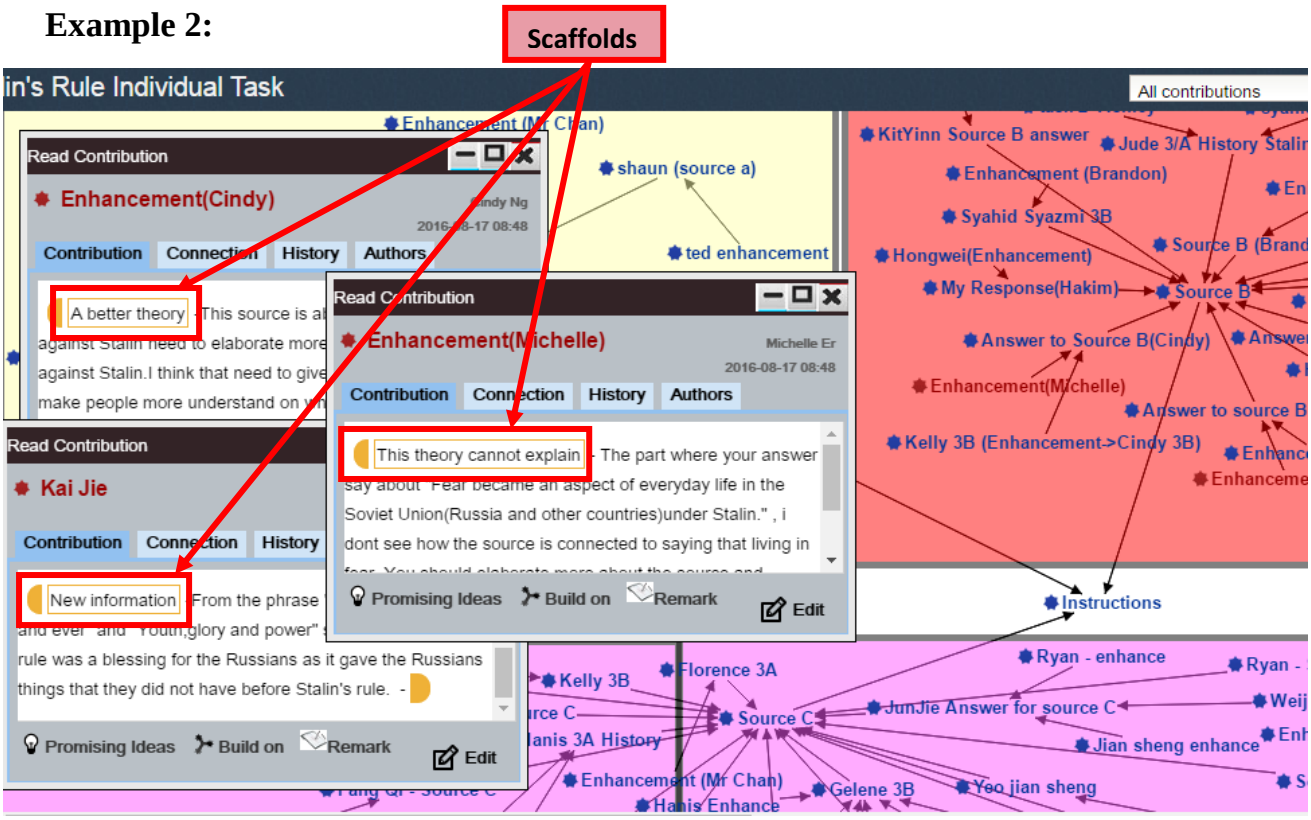
- During whole-class discussions, walk students through the KF database and highlight clusters of notes (build-on notes).
- Ask 'how' and 'why' questions.
- Introduce information from different sources.
- Get students to expand their ideas by writing down new questions. This can be done on KF or on pen-and-paper (e.g., idea cards). [There can be a break after lessons so teachers can have a chance to read students' postings]
- Think about leading class discussions based on selected students' notes. This encourages ownership of learning.
- During verbal classroom discussions, encourage students to use similar sentence starters to KF, i.e., I need to understand…
- Work together with your class to consolidate facts and explanations on KF.

Here are two examples showing students using the scaffolds in KF.

Example 1:



Example 2:



4. Idea Improvement

Idea improvement is the key mechanism for knowledge building (Scardamalia & Bereiter, 2006) and knowledge creation (Tan & Tan, 2014). In a knowledge building classroom, all ideas are treated as improvable. Students are not only responsible for improving their own ideas, but also for improving the ideas of their peers, thus advancing the ideas of the class as a whole.

However, while the generation of ideas is easy and common, improving on ideas is a considerably more difficult process, as it requires a deep understanding of a particular topic. On KF, idea improvement usually occurs in small increments over time, and due to contributions from many people. When students present their ideas about a particular topic on a shared platform like KF, these ideas can be improved through productive discourse amongst peers. Moreover, KF enables every single idea to be captured and archived, and to be revisited and improved on continuously.

Alternatively, students can also improve on ideas using pen-and paper, e.g., using the students' ideas worksheet (exercise 4 & 5 in Appendix C).

At this stage, **Students** should be:

- Integrating new ideas with existing knowledge
- Generating new examples
- Generalising/Justifying/Applying

KB scaffold: *A better theory*

Strategies to guide idea improvement:

- Help students work towards constructing coherent interpretations by getting them to read and connect their ideas and information, and evaluate different perspectives.
- Allow time for the process of synthesising ideas. This synthesis could happen as a:
  a) Individual's note or group's note of "pulling our knowledge together" (with references to peer's notes)
  b) A PPT presentation or other artefacts synthesising ideas about a problem.
- Decide the groupings in which students would be exploring their inquiry questions; get them to read and collate ideas in their groups.
- Reflect on students' collective questions and ideas on KF from previous lessons and see how they could be used for both the current lesson and subsequent lessons.
- Based on students' ideas and questions, you can plan the following: introduce questions/information/experiments/resources/videos, to broaden students' scope of information.

Here is an example of an activity that was designed to facilitate idea improvement:

Topic: 'Respiratory System'

Activity: The teacher designed a scenario of a patient ("Uncle Yong") suffering from certain symptoms, then got students to make sense of the information given and figure out how his problems could be resolved, as well as which body system(s) was most critical in these symptoms (Fig. 11).

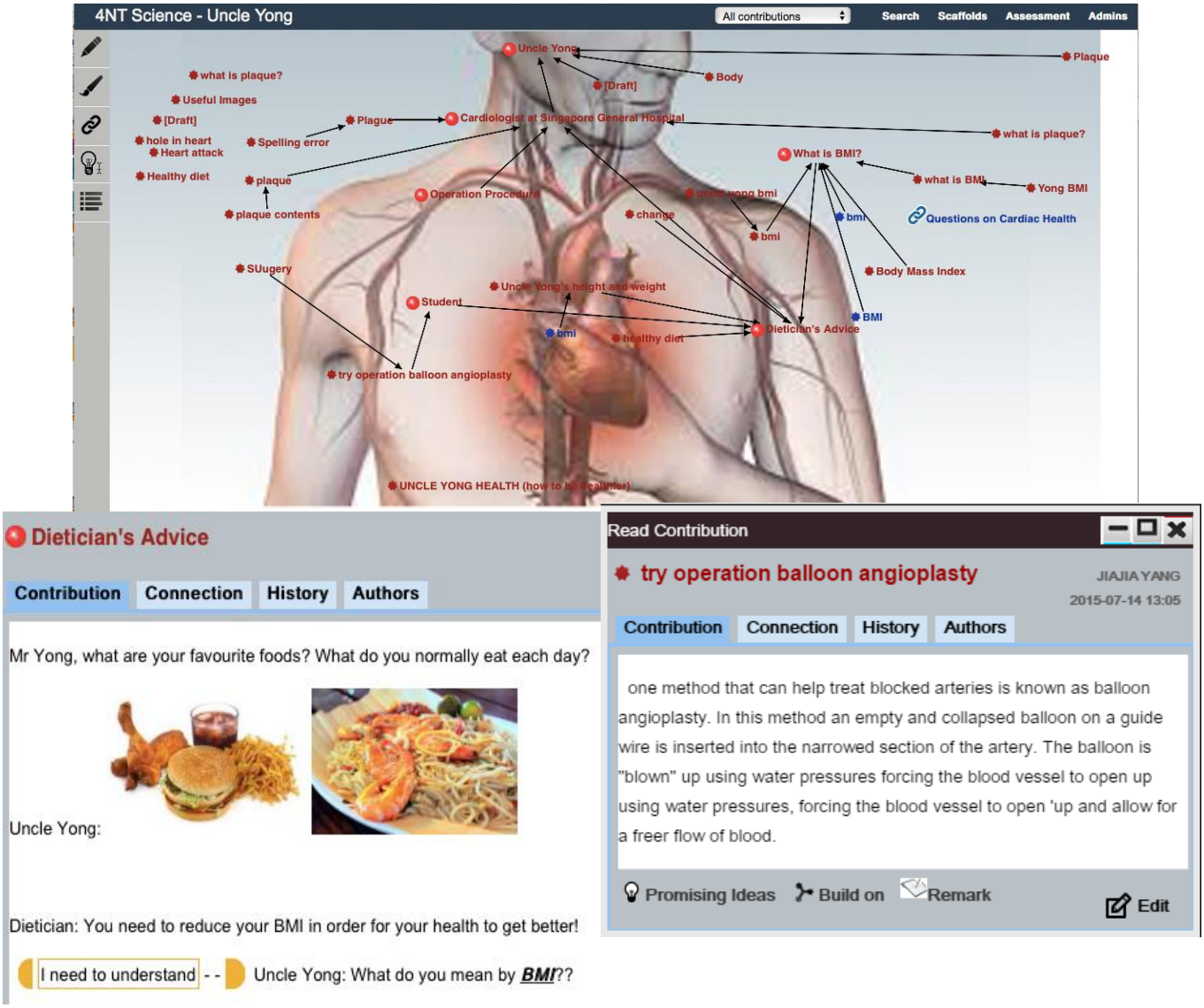


Figure 11. An activity about the respiratory system, designed to facilitate idea improvement.

Over the next few pages, we will demonstrate the process of idea improvement in detail through two examples.

Example 1

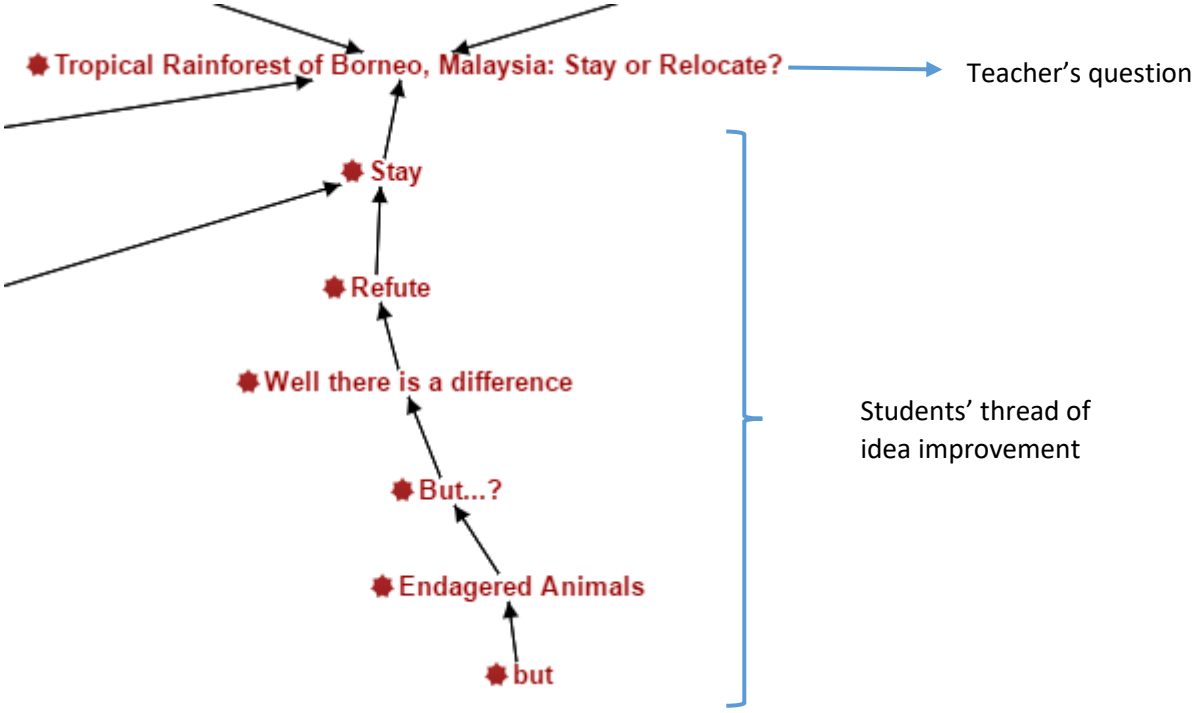


Figure 12. A thread of idea improvement, based on the inquiry question 'Stay or Relocate?'

Figure 12 above demonstrates a thread of ideas amongst students on KF as they improve on each other's ideas in their attempt to answer their teacher's inquiry question: "Tropical Rainforest of Borneo, Malaysia: Stay or Relocate?"

This web of idea improvement is shown in detail on the next page (Fig. 13).

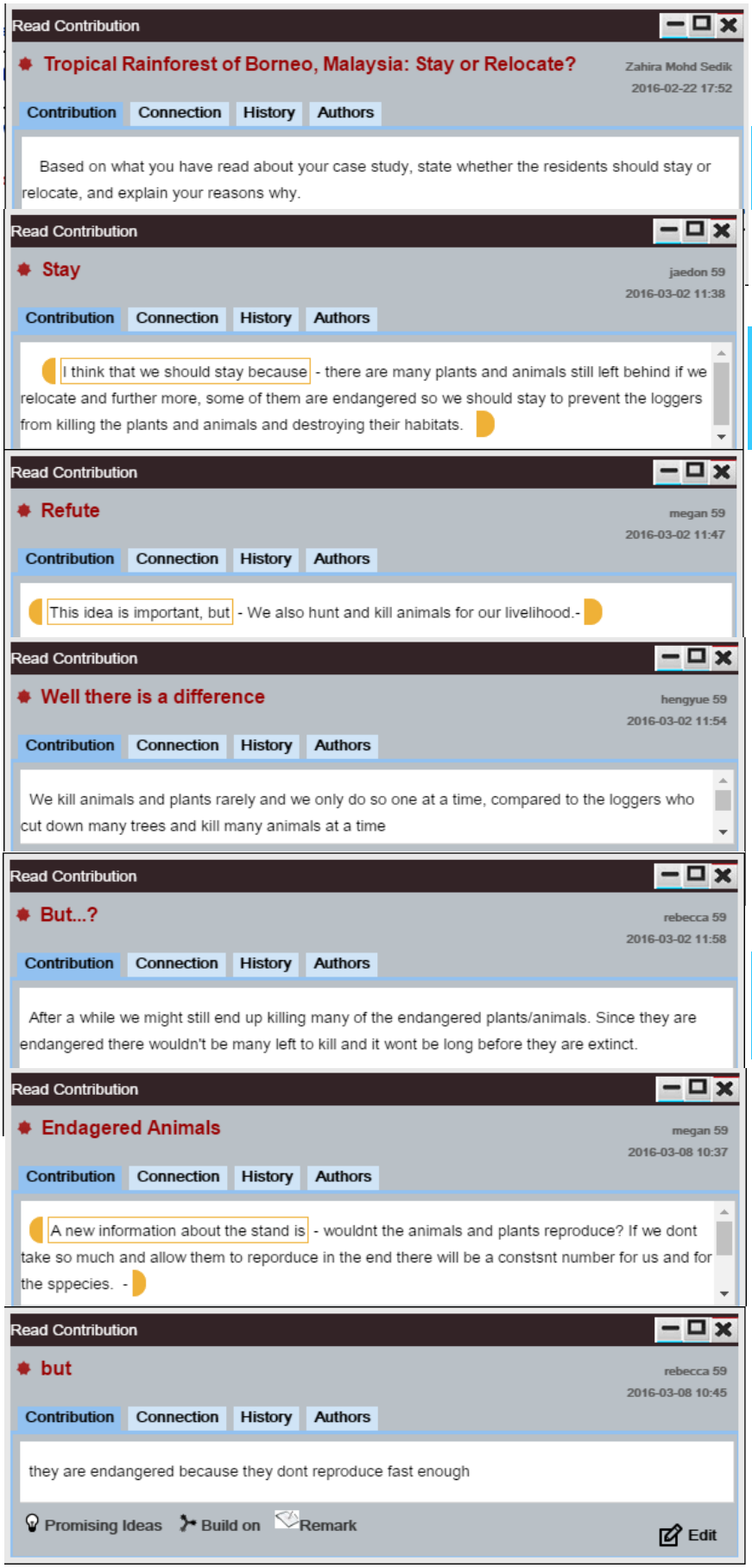


Figure 13. A detailed thread of idea improvement (1st example)

Teacher poses the inquiry question: stay or relocate?

Student 1 answers that residents should stay and gives his reasoning.

Student 2 presents a conflicting point to student 1's reasoning.

Student 3 opposes student's 2 point with an explanation.

Student 4 puts forth a different point of view that synthesises student 2 and 3's notes.

Student 2 questions student 4's stand and states her explanation.

Student 4 answers student 2's question with her reasoning.

Example 2

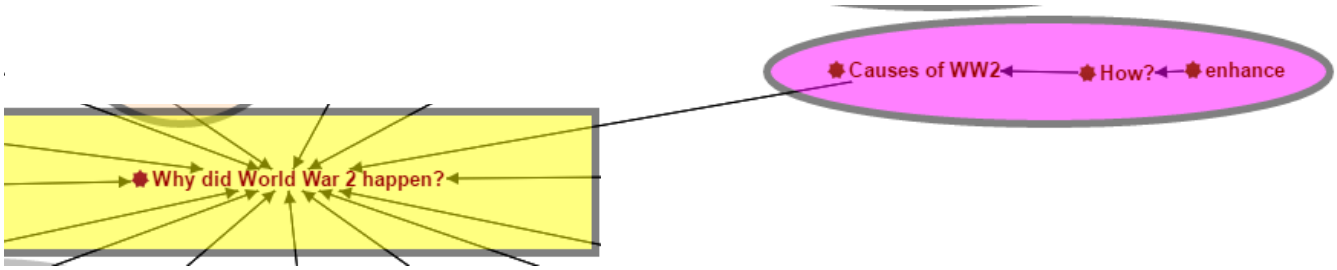


Figure 14. A thread of idea improvement, based on the inquiry question 'Why did WW2 happen?'

Figure 14 above shows a thread of ideas amongst students on KF as they critique and improve on each other's ideas in order to gain a deeper understanding of the topic while answering their teacher's inquiry question: "Why did World War 2 happen?" The details of this web of idea improvement is shown in Figure 15.

Teacher poses the inquiry question: Why did World War 2 happen?

Student 1 answers the question and supports his answer with evidence and elaboration.

Continued on next page

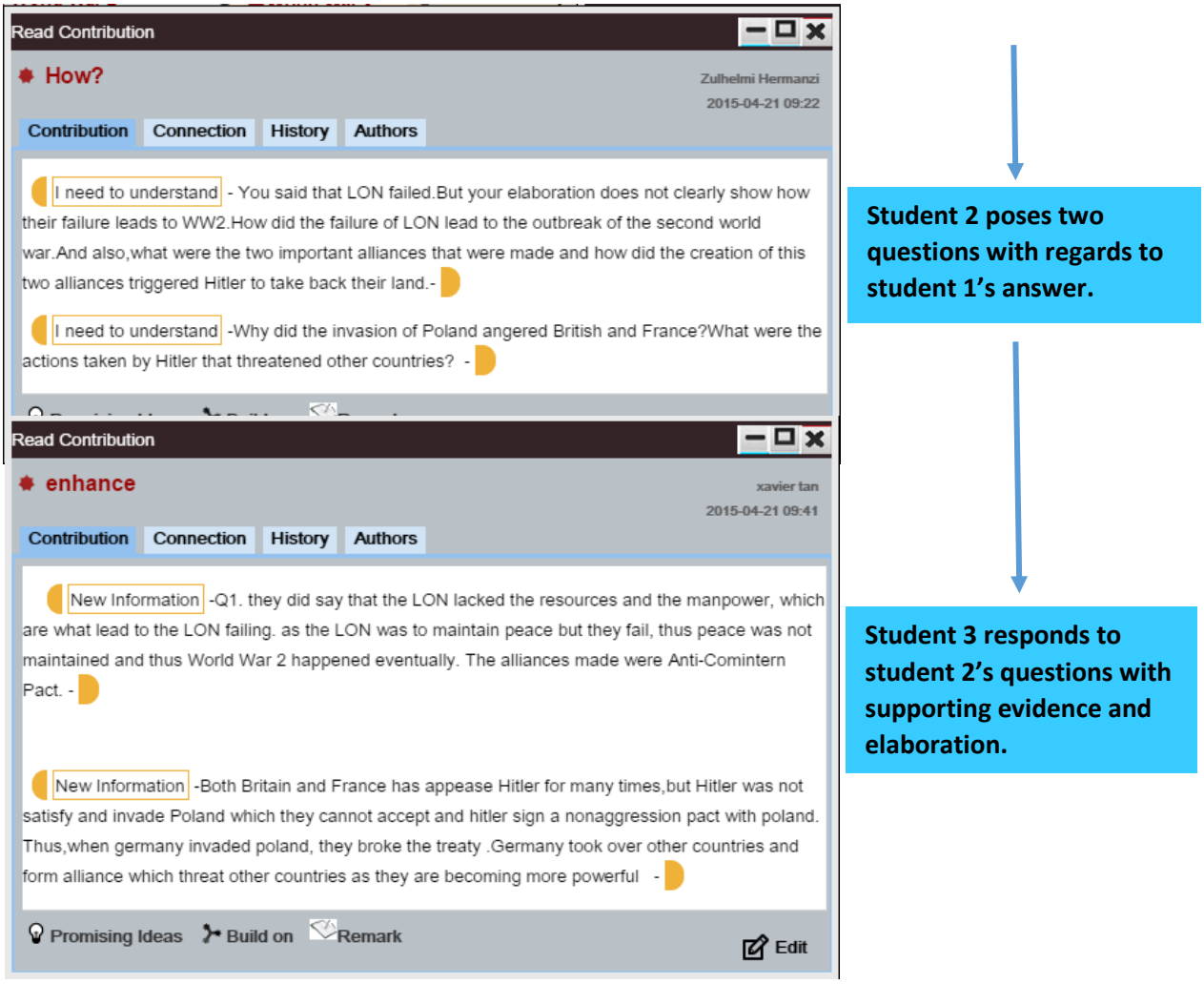


Figure 15. A detailed thread of idea improvement (2nd example).

5. Understanding Assessment (Recognising KB in class)

Now that students have been connecting and improving on ideas, it is important that you are able to understand students' development and provide space for them to conduct self-assessment. To understand students' development is to recognise and evaluate the knowledge building process in class. This can be done in two ways:

a) Students' notes and threads of ideas on KF can be used to assess individual contributions as well as the collective work of the class.
b) Students' reflections and self-assessment can give a clear insight as to what and how they are learning.

At this stage, **Students** should be:
- Creating learning artefacts
- Reflecting on their learning process

***KB Scaffold**: I need to understand*

A) Reading threads/notes on KF

When reading students' notes on KF, you can ask yourself these questions to guide your evaluation:

1. Is the question asked a fact-seeking question or an explanation-seeking question?

2. In terms of scientific literacy skills (also applicable to geography): Do you see the following characteristics in the thread when students try to explain the question?

   a. Using an ***unelaborated fact***

- Description of terms, phenomena, or experiences without elaboration.
- E.g., the umbra is the darkest part of the shadow.

   b. Using an ***elaborated fact***

- Elaboration of terms, phenomena or experiences.
- E.g., the angle of incidents equals the angle of reflection; which means if you shine a light source on a flat mirror then the angle you shine the light on the mirror is the angle it will reflect.

   c. Writing an ***unelaborated explanation***

- Reasons, relationships, or mechanisms mentioned without elaboration.
- E.g., shadow is made up when light hits an opaque objects and so then it makes shadow, the shadow is always attached to an opaque object.

   d. Writing ***an elaborated explanation***

- E.g., a shadow is made by an object in front of a light stream. The light can't go around and then no light get behind the objects and it's dark.

3. In terms of the 'scientific-ness' of the idea: Do you see the following characteristics in students' thread of notes?

   a. Sharing a ***Pre-scientific idea***

- Misconception; naive conceptual framework.
- E.g., "I think shadows exist because they show you things are there. Everything has a shadow unless it's underground."

   b. Sharing a ***Hybrid idea***

- Misconceptions that have incorporated scientific information but show mixed misconception/scientific frameworks.
- E.g., "A shadow is sunlight that reflects off your body and makes almost the same shape but at different times either it's smaller or bigger. In the morning I think that the shadow is bigger and when it comes close to night your shadow gets smaller ..."

   c. Sharing a ***Basically scientific idea***

- Ideas based on scientific framework but not precisely scientific.
- E.g., "... if there is no light, there can't be a shadow."

   d. Sharing a ***Scientific idea***

- Explanations that are consistent with scientific knowledge.
- E.g., "... a shadow is created by the sun or artificial light hitting an opaque object. Shadows change size either depending on the size of the object or the light source, say the sun's position ..."

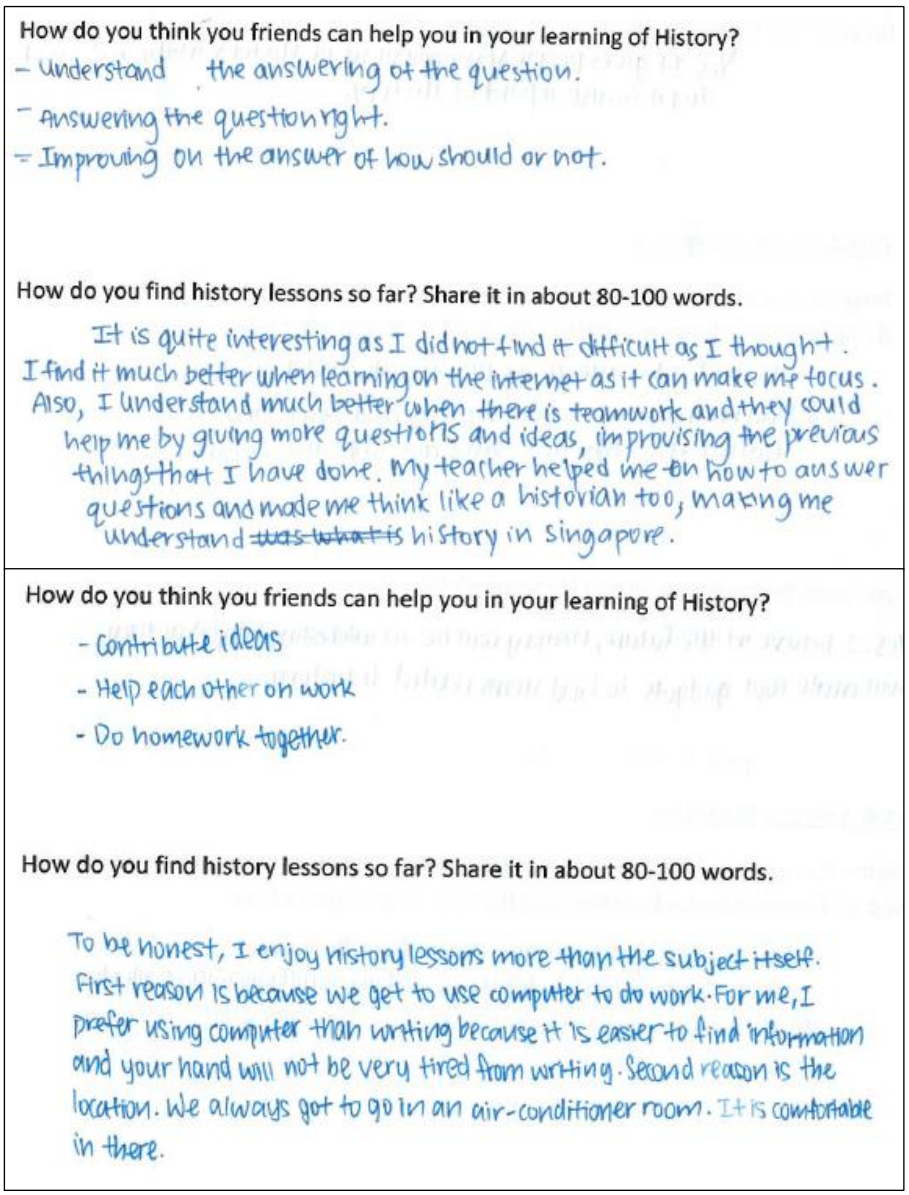
You can refer to Appendix D for examples of how students' notes can be interpreted.

B) Students' self-assessment/reflection

In a knowledge building classroom, students must also be involved in assessment, as all learners share a collective cognitive responsibility. This is different from a traditional classroom, where only the teacher takes on the responsibility of understanding what is happening, i.e., knowing if students are learning. Opportunities for self-assessment and reflection should be provided to students at regular intervals. These can be in the form of pen-and paper artefacts (e.g., surveys) or on an online platform (e.g., on KF itself). These two examples of self-assessment are shown in examples 1 and 2, respectively.

Example 1

A teacher created a written survey for his students to complete at the end of his sequence of KB lessons. Figures 16-18 are some snapshots of the survey questions and students' reflections.



How do you think you friends can help you in your learning of History?

- Understand the answering of the question.
- Answering the question right.
- Improving on the answer of how should or not.

How do you find history lessons so far? Share it in about 80-100 words.

It is quite interesting as I did not find it difficult as I thought. I find it much better when learning on the internet as it can make me focus. Also, I understand much better when there is teamwork and they could help me by giving more questions and ideas, improvising the previous things that I have done. My teacher helped me on how to answer questions and made me think like a historian too, making me understand ~~was what is~~ history in Singapore.

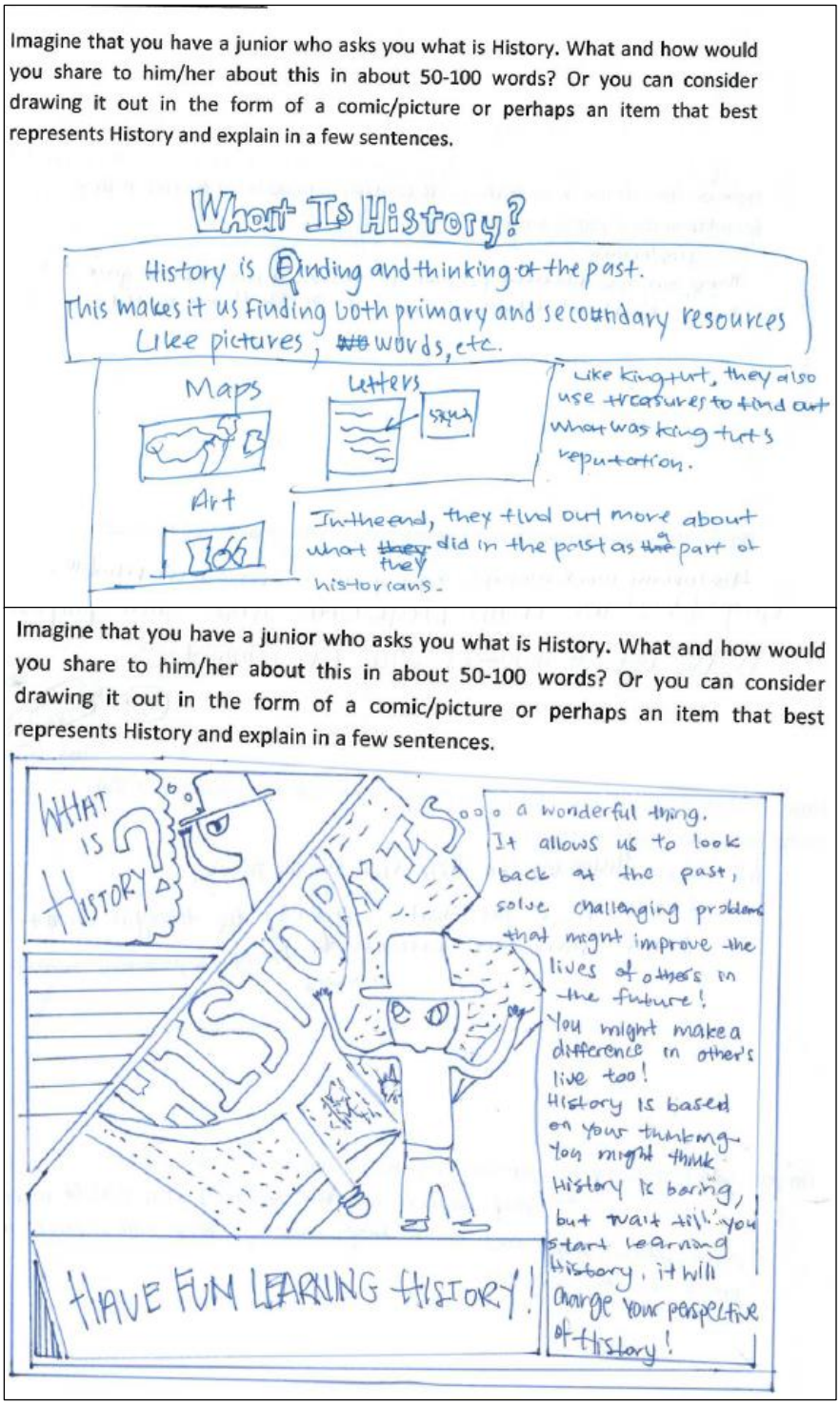
How do you think you friends can help you in your learning of History?

- Contribute ideas
- Help each other on work
- Do homework together.

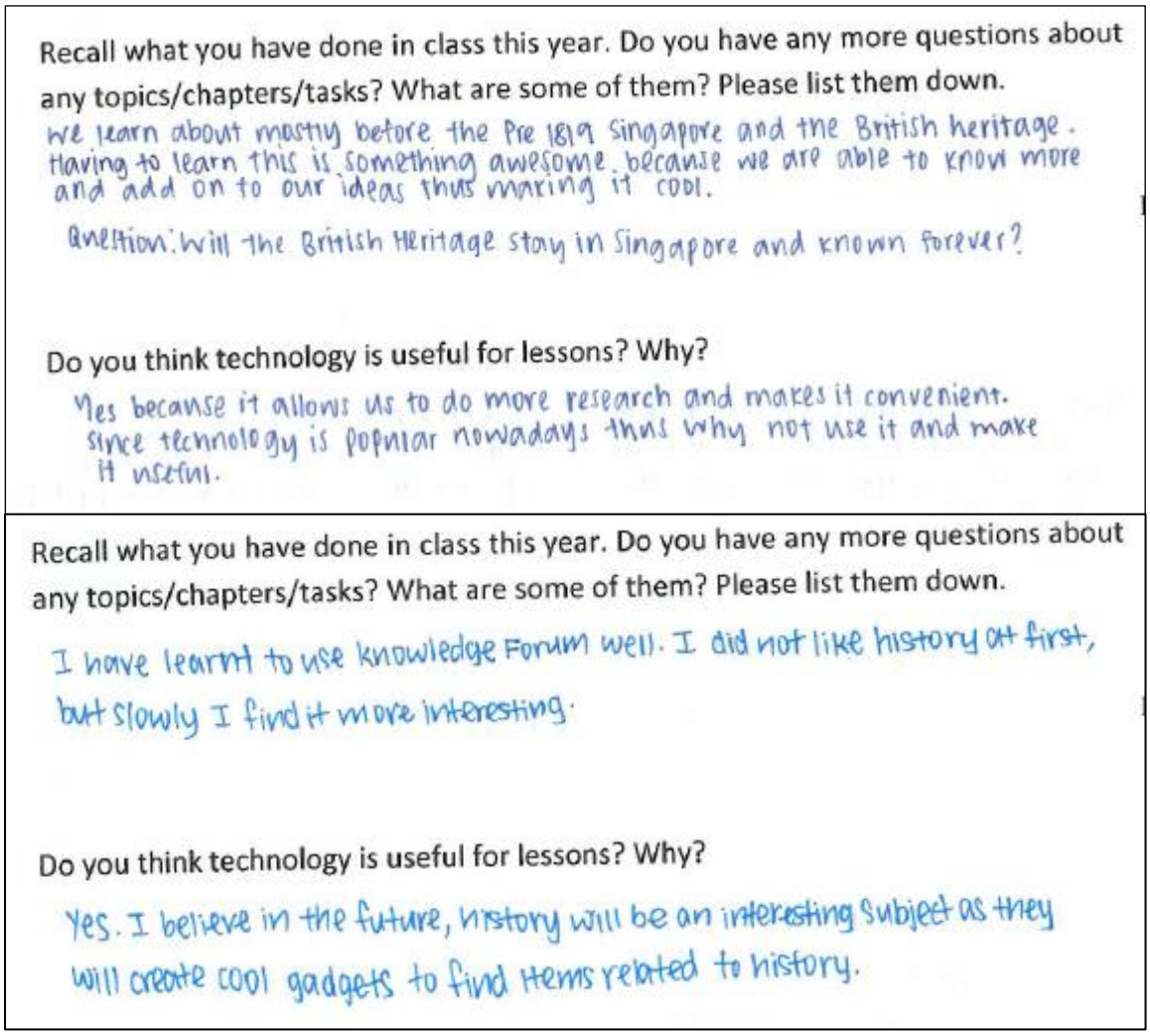
How do you find history lessons so far? Share it in about 80-100 words.

To be honest, I enjoy history lessons more than the subject itself. First reason is because we get to use computer to do work. For me, I prefer using computer than writing because it is easier to find information and your hand will not be very tired from writing. Second reason is the location. We always got to go in an air-conditioner room. It is comfortable in there.

Figure 16. First snapshot of two different students answering survey questions that their teacher created.



<u>Figure 17.</u> Second snapshot of two different students answering survey questions that their teacher created.



<u>Figure 18.</u> Third snapshot of two different students answering survey questions that their teacher created.

Example 2

A teacher posted reflection questions on KF for his students to answer at the end of his sequence of KB lessons. Below (Fig. 19) is a snapshot of some of the reflection questions.

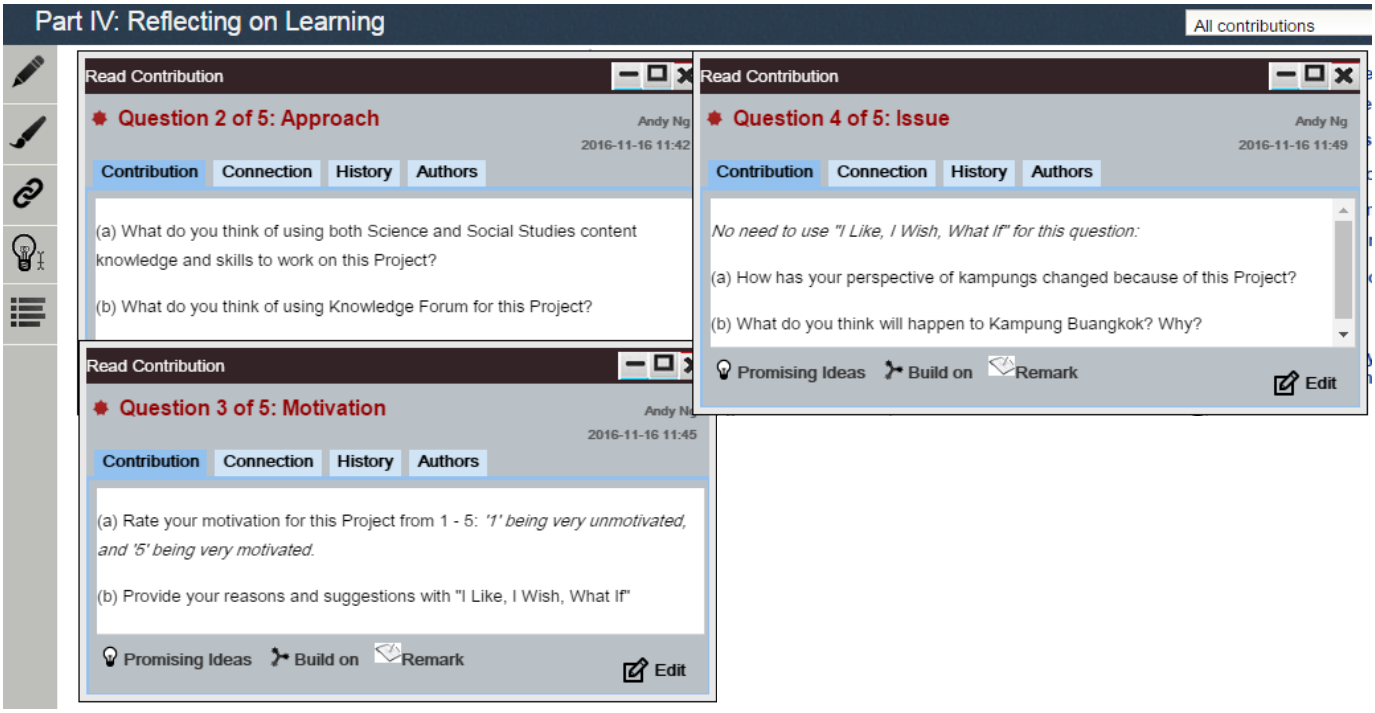


Figure 19. Examples of some of the reflection questions that a teacher posted to his students on KF.

As seen in Figure 19, the teacher posted a variety of reflection questions for students. They involved the lesson approach (e.g., "what do you think of using Knowledge Forum for this project?"); students' motivation (e.g., "rate your motivation for this project"); and the issue of discussion (e.g., "how has your perspective of kampungs changed because of this project?"). Examples of students' reflections in answer to the teacher's questions are shown on the next page in Figure 20.

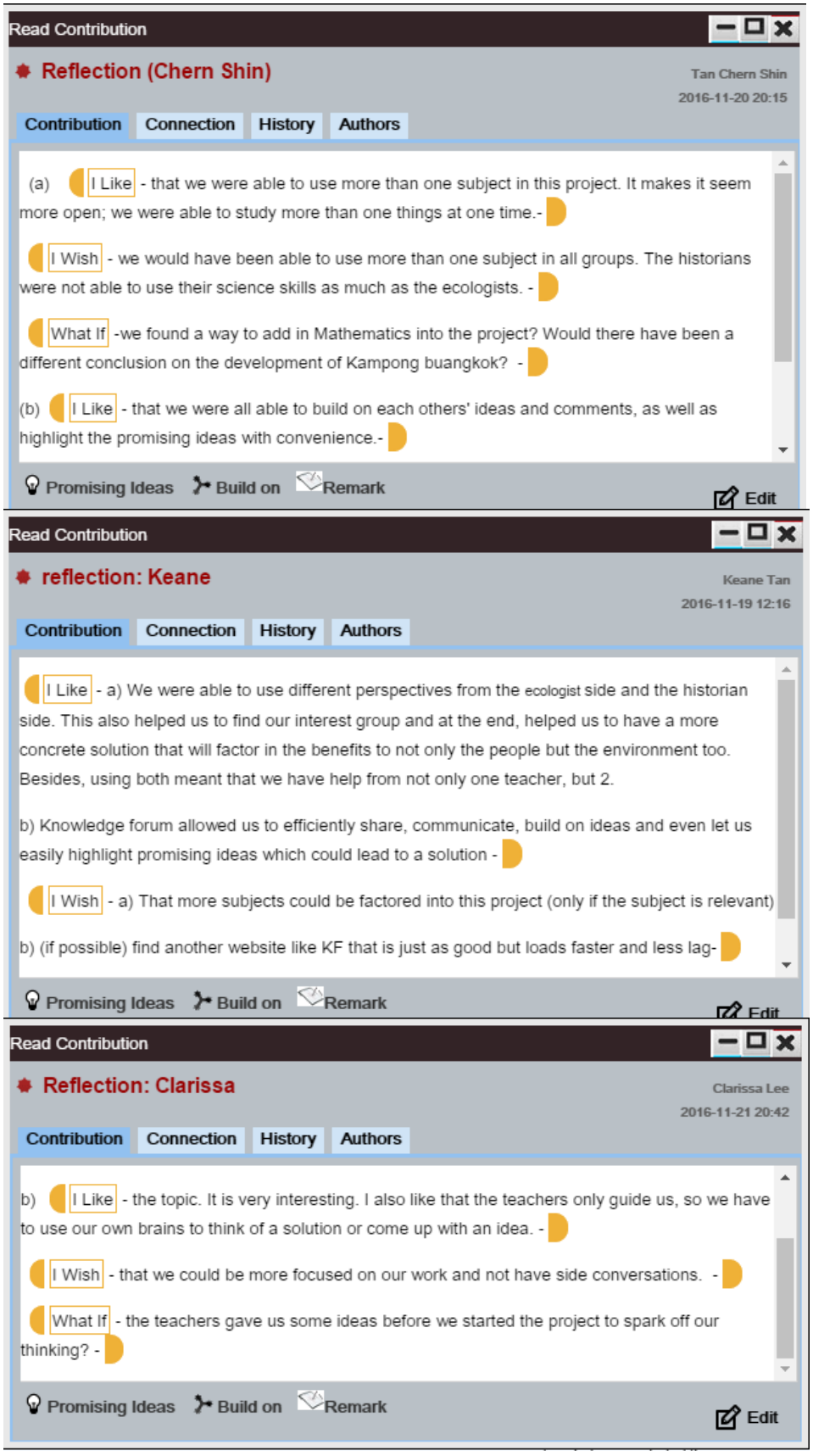


Figure 20. Examples of three different students' reflections, answering the reflection questions that their teacher posted on KF.

Strategies to guide assessment and reflection:

- Students' reflections should be concrete artefacts, i.e., either online on KF (e.g., an e-portfolio) or offline on pen-and-paper (e.g., a KB journal).
- For individual reflection, get students to copy or reference their classmates' notes onto their portfolio note to summarize what they have learnt so far.
- Encourage reflective thinking of both the inquiry process and the synthesis process (from stages 1-4).
- Allow students to review and consolidate their learning based on KB classroom discussions.
- Get students to write their "journey of thinking" to reflect on the whole KB process and their learning (Fig. 21).

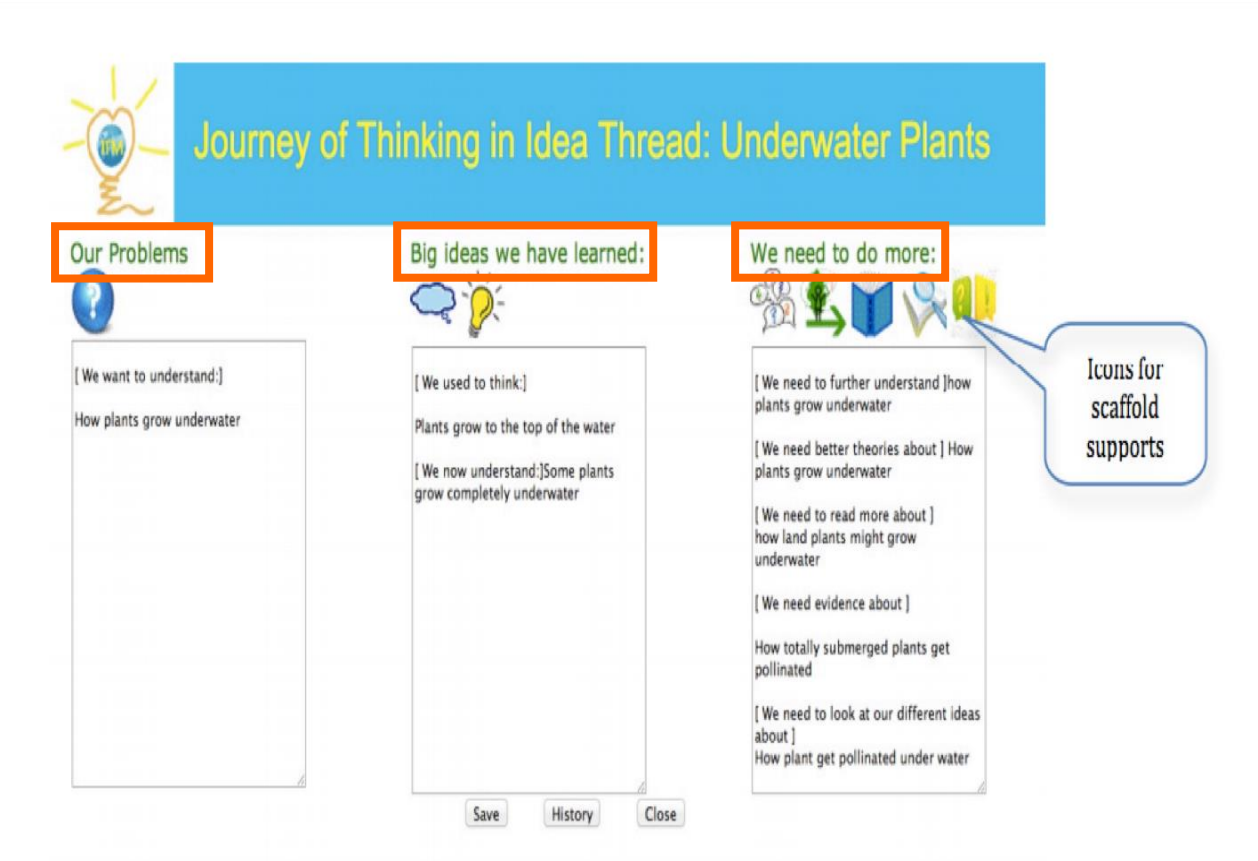


Figure 21. Journey of Thinking

Summary

KB Pedagogical Framework (Teacher's Role)

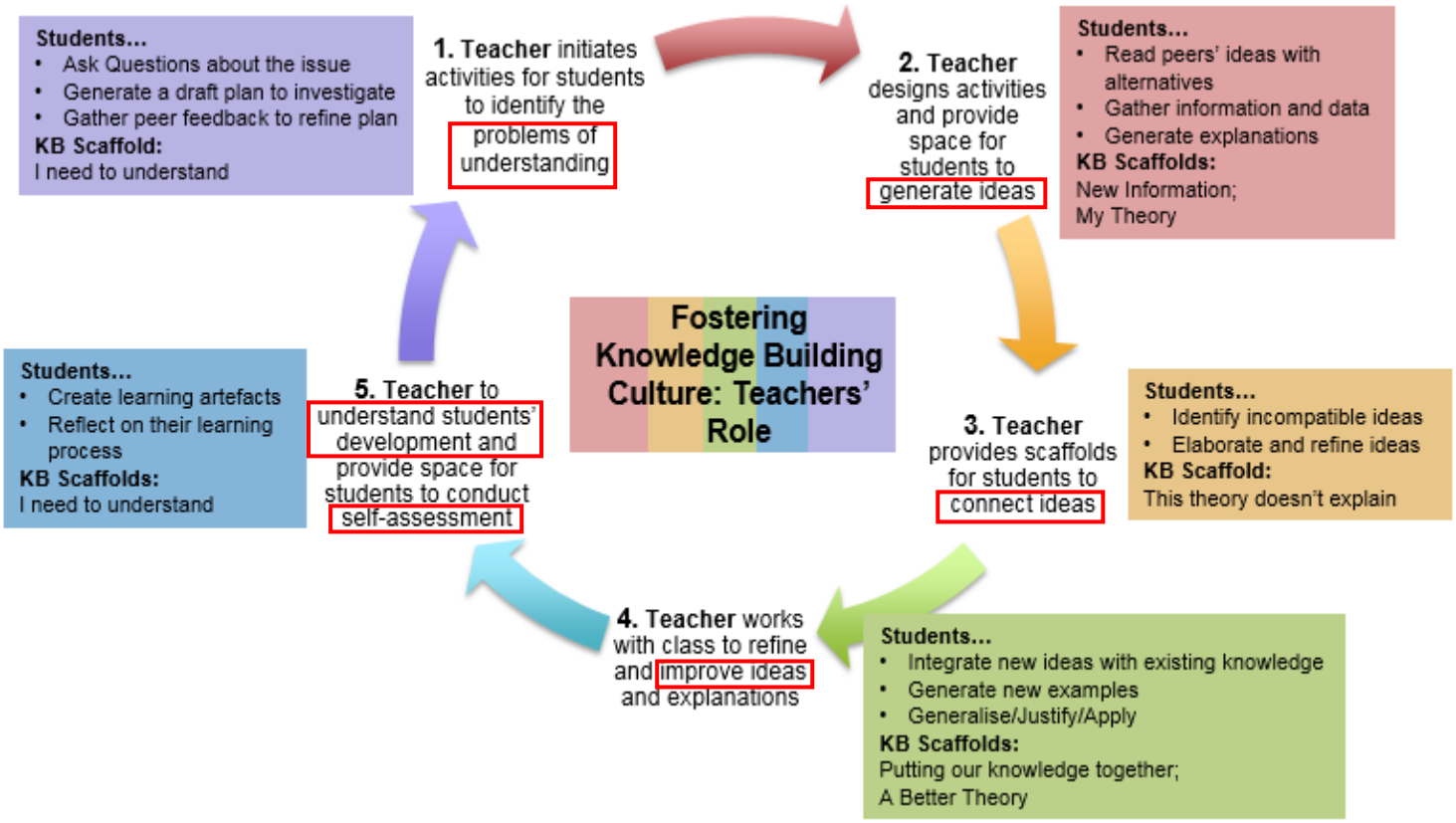


Figure 22. The KB pedagogical framework foregrounding teacher's role.

Above is the KB pedagogical framework that will guide your planning and designing of lessons. The framework foregrounds teacher's role as the main frame, and students' role as the supporting frame.

Table 3 on the next page will briefly explicate the teacher's and student's role at each stage of the process.

Table 3. Roles of the teacher and the student in the KB pedagogical framework

Stage	Teacher's Role	Student's Role
1. Initiating activities	a) Foster a KB culture; set rules of engagement b) Trigger activities to rouse interest/curiosity	Students should be deep in inquiry: - Asking questions - Theorising based on prior knowledge
2. Idea Generation	a) Providing a safe environment for students to generate ideas b) KB discussion/talk c) Ensuring students' ideas are captured, whether online or offline	- Constructing explanations and evidence - Reading and citing research and examples - Recording their ideas
3. Idea Connection	Apart from providing students with scaffolds, encourage: • Reading of notes • Building-on of notes • Positive behaviour online	- Elaborating and refining explanations - Reading peers' ideas and providing alternative perspectives - Identifying potentially incompatible ideas - Referencing peers' notes
4. Idea Improvement	a) Highlight important and promising ideas b) Introduce contrasting information c) Reference students' notes d) Pull out students' reflective notes	- Integrating new information with existing knowledge - Synthesising and restructuring knowledge - Generating examples
5. Understanding assessment	Look at students': • Contributions • Participation • Emergent ideas • Idea threads Provide students with the opportunity to do self-reflection	- Reflecting - Further development of ideas (looking at idea threads) - Generating more ideas

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Practitioner Paper 1

Knowledge Building Pedagogy and Technology: Enacting Principle-Based Design in History Classroom

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Abstract: This study traced the pedagogical moves adopted by a teacher in taking a principle-based approach to designing knowledge building environment (pedagogy and technology) for history lessons. Students, in turns, engaged in mature historical analysis through collaborating and reflecting on their theories on historical inquiry suggesting that Knowledge Building pedagogy and technology are conducive to mature historical thinking. We measured the impact of this approach by the sophistication of students' theories and explanations in terms of the level of historical thinking. Results showed encouraging trends but also pointed towards ways to enhance knowledge construction in history lessons.

Introduction

The essence of knowledge building (KB) classroom focuses on engaging a group of learners in discourse and advance collective knowledge while ensuring that this knowledge is accessible for future use (Lee, Chan, & van Aalst, 2006; Scardamalia & Bereiter, 2003). Such classroom depends largely on teacher's ability to translate a set of Knowledge Building principles to design lessons and organise instruction (Chai & Tan, 2003) in a way that engages students in mature work in the discipline, enculturating them in a learning culture that values their initiation to contribute, add values to ideas, and advance collective knowledge through collaborative discourse (Bereiter, 2002). KB classroom includes integration of Knowledge Forum (KF), an online communal discourse platform that has scaffolds to support students in creating and linking notes (Scardamalia, 2004). In this study, we look at how a history teacher translates knowledge building principles into designing a history classroom to build students' historical thinking.

Knowledge building in a history classroom

Existing literature on knowledge building pedagogy has predominantly focused on science as the subject matter. Bereiter and Scardamalia (2012) explained that generating ideas about scientific phenomena involves exploring scientific laws or principles, whereas generating ideas about social historical phenomena involves exploring theories of a specific case. This difference in the knowledge building practices of the two subjects illustrates that improving knowledge building pedagogical practices for history continues to be an important agenda (Tan, So & Yeo, 2014).

Schema, historical thinking and use of historical concepts

In the learning of history, it is important that students are given the opportunities to make sense of the world as they explore the seemingly distant and dense historical content. They must develop a robust schema, a mental model, to organize and interpret the vast amount of information in a history text. Research on novice versus expert performance (Voss & Wiley, 1998) has indicated that expertise in history requires a mental model that allows for reasoning and problem solving. This schem a is an important dimension in developing historical literacy in students. Historical literacy provides a consistent framework upon which to develop historical thinking and students' ability to construct historical concepts. Seixas and Peck (2004) argue that the role of history education is to work with students' fragments of thinking and develop them, so students can learn to think historically and have a better basis for sense-making.

Teachers' principle-design approach to designing the inquiry activities

The teacher has six years of teaching experience and three years of experience with KB practice. In this study, he worked with 39 fourteen-year-old students (19 boys and 20 girls) in an express class (middle-achievers) in a government-aided school. KB pedagogy and technology was adopted throughout the year but this series of lessons were recorded over two week in term three of the school year. He started this series of lesson by designing a set of cognitive scaffold based on the historical concepts defined in the national curriculum document. These cognitive scaffolds took the form of sentence starters to support students in writing notes on Knowledge Forum,

a multimedia community knowledge space. The software provides knowledge building supports both in the creation of notes and in the ways they are linked, it also allows for revisions, elaborations, and reorganizations over time. These scaffolds also serve to support students in navigating the source materials, reflecting their understanding of the information, and crafting explanations of the historical matter. The following segment is a narrative derived from teachers' reflection on his lesson design when the sequence of lessons was completed.

Sparking curiosity (inquiry phase)

Teacher wanted to interest the students in the history topic by engaging students in their own initial questions and ideas about the topic of Japanese occupation. He got the students to post their initial thoughts online and explained to students that the sequence of lessons would be run according to their ideas and inputs in class (Democratizing Knowledge). He also ensured that students embraced the rules of engagement that all ideas are valuable and must be worked upon such that there is diversity of ideas. Example of the different initial questions surfaced by students were, "how was life tough during Japanese occupation?", "Blessings during Japanese occupation?"

Gathering evidence by developing examples of group sources

In a subsequent lesson, the teacher facilitated a classroom discussion around students' theories posted online (students' notes on KF was projected on the wall throughout the discussion). Students suggested that they need to find sources to verify and improve their explanation and theories. They then set off to search and upload relevant sources onto Knowledge Forum, they were encouraged to justify their choice. Students understood that they have to find their way to advance their theories (Epistemic Agency) and they were given opportunities to talk about their contribution in class in subsequent lessons.

Exercising reasoning and reflective thinking

Teacher then built on students' posting that questioned the relevance of the source and got the rest of the students to derive pointers they learnt about relevance before commenting on the rest of the post (Epistemic Agency and Constructive use of sources). In so doing, students were broadening their concepts of 'relevance'. For example, they have learnt that relevance is not about having the source agreeing with the statement. A contradicting source can also be relevant as long as the content relates to the given topic/issue. All through these lessons, the teacher focused on getting students to demonstrate historical thinking surrounding the concept of relevance, the concern of covering historical events and facts was secondary to the development of historical thinking.

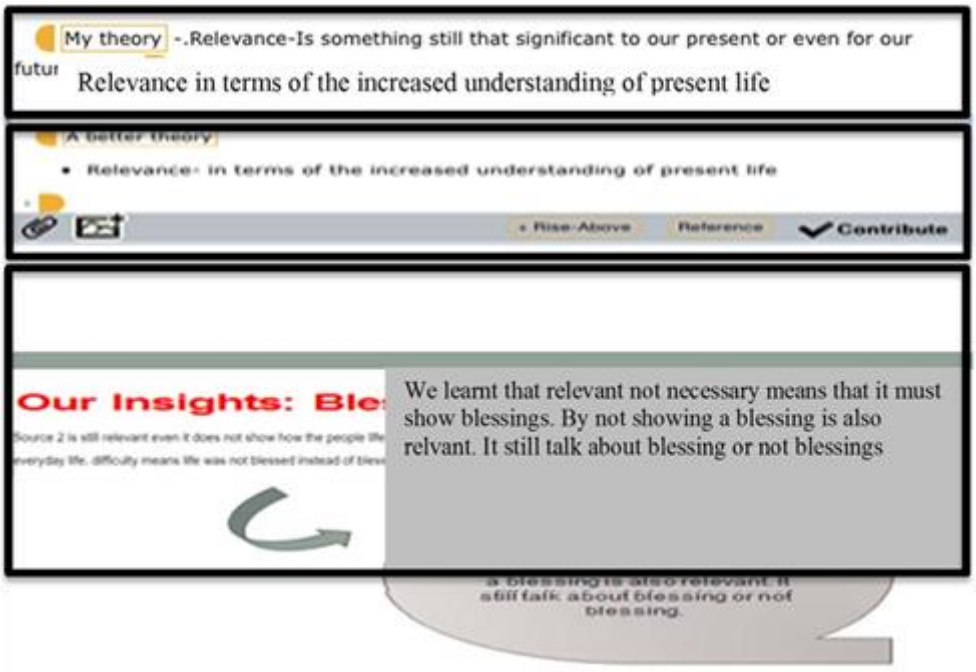

Figure 1. Three sets of students' notes using scaffold "my theory", "I need to understand", and "rise-above".

Rise above

At the final stage of inquiry, the class was tasked in groups to craft explanations that incorporated and synthesized prior knowledge, new information and new understanding acquired throughout the process to respond to the overarching question, "Was it true that Japanese Occupation in Singapore only brought forth negative impacts to the people?". This question was synthesized from students' questions in first view. Upon studying students' responses, teacher reflected that he saw a shift in students thinking. Students were able to adopt different sets of KB scaffolds to help them progress in the writing of their group response, they showed a more robust view of the topic by challenging some conventional thoughts and they were able constructed more diverse yet coherent explanations. Below is a snippet of students' rise-above note which the teacher analysed as "(in the note) students has constructed a non-monolithic thinking, adopt both perspectives [non-conventional approach in the study of JO which usually focuses on negative]."

> Japanese Occupation helps people to come together as one, regardless of races. This is very different from British time. This is something that is positive to the people in Singapore. But, we also agree that there are also sources showing Japanese Occupation also bring forth negative impacts. (snippet of students' note taken from KF)

Analysis

To find out how the KB environment impacted students' development of historical literacy skills, 586 students' notes collated across three weeks and two different KF views on different aspects of Japanese occupation posted KF were analysed using the coding scheme in Table 1. (KF Views are 'pages' on KF that provide a visual organization for notes. A KF view allows one to see all related notes and it represents related ideas and discussion strands.) The notes that were analysed were mainly written with sentence starters such as "my theory", "a better theory", "pulling our knowledge together", "new information that depicted students' theories, explanation, and rise-above.

The coding scheme is built from existing literature that has identified six distinct but closely related historical concepts as a framework for assessing historical literacies skills. The six concepts are: Historical Significance; Evidence (Use of Historical Sources); Continuity and Change; Cause and Consequence; Historical Perspective; and Moral Judgement. In the present study, a gradation scheme was created to chart developments in students' understanding of these six historical concepts across the three KF views. The gradation scheme is as follows (Table 1):

Table 1: Coding scheme on progression of students' historical literacies skills based on level of sophistication of notes defined by the integration of historical concepts

Categories	**Descriptions**	**Examples**
Level 1	No awareness of historical concepts	-
Level 2	Superficial understanding of historical concept as a way to "answer" to a question.	*"Source 2 answered the question of how tough days were back then during the Japanese occupation."*
Level 3	Use of historical concept as part of the explanation.	*"My theory -Source 3 is relevant because the source shows that how hard it is to get food for living."*
Level 4	Elaboration of historical concept in explanation (usually involves personal thoughts or theories)	*"My theory -source 1 show(s) us how life under japanese occupation was tough, i agree as it shows us how Elizabeth choy got torture by iapanese occupation and the method of making her husband feel useless. Back then women does not have any protection"*

Findings

It is generally evident from the results that students' historical literacy skills improved significantly over the course of the KB lessons. The overall pattern is that, as the project progressed and lessons continued, students' historical literacy skills were showing increasing level of sophistication. With such positive shift in students' historical literacy, the teacher reflected and surfaced two points to be considered in his next cycle of lesson design, first, he felt that there could be higher level of autonomy given to students throughout the inquiry process and second, he felt that more effort could be used to unpack the rise-above principles to students so as to allow them to assess and own the new knowledge they created throughout the lessons.

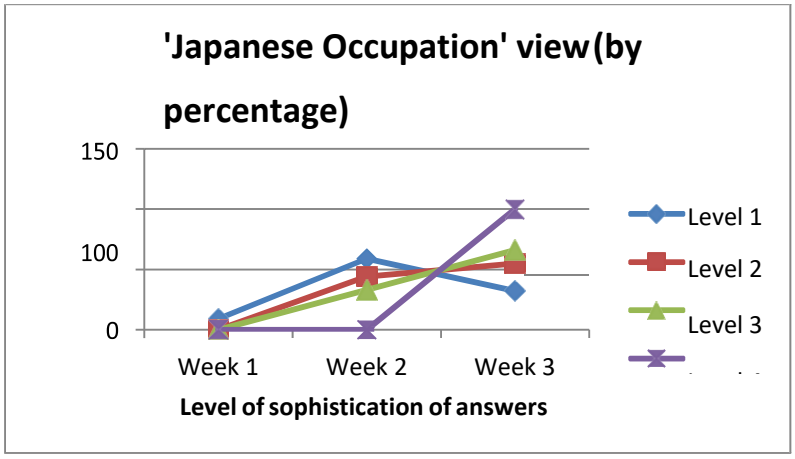

Figure 2. Level of sophistication of students' posting online across three weeks.

Conclusion and implications

In summary, results reflect that a KB environment can benefit students' learning of History, as it increases students' development of interest in the subject, as well as their historical thinking. The key role of history teacher lies in their interaction with students. Such interactions includes a collective effort in posing guiding questions, having rich conversations, providing scaffolds to help students see patterns in history events and text and finally, facilitating students' independence in knowledge construction process.

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Practitioner Paper 2

Understanding Teacher's Principle-Based Practice in Sustaining Knowledge Building Practice in a Science Classroom

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Abstract: In this paper, we trace one teacher's attempt to design knowledge building classroom in a principled way for a class of low achievers. Through the narrative of teacher's effort in planning, enacting, and reflecting on knowledge building practice, we hope to provide a perspective for practitioners to construct 21st century teaching and design capability. Understanding teachers' work in their natural setting is important in encouraging a culture of learning designers among teachers; one that centers around students' thinking and learning more than teachers' judgment. Such a principle-based approach relies on teachers' interpretation of Knowledge Building principles and their translation of these principles into daily practice. As the idea of teachers as designers of learning is rather under-represented in practice, we hope such reflective journeys will provide a lens to other practitioners and challenge the notion that such a principled-based approach is only theoretically sound and has little practical value.

Introduction

There has been a significant effort to shift from individual inquiry to collaborative inquiry in educational approaches so that student learning remains vibrant and robust, thus ensuring that they are ready to face the challenges in this world of rapid change and technological advancement (Scardamalia & Bereiter, 2006). Although the 'why' of the shift is clear, many teachers still grabble with the 'how'. In recent years, we have seen an extensive professional development effort aiming to prepare teachers to embrace such a shift while continuing to be efficient and effective in their work. In this paper, we trace one teacher's attempt to reflect and design knowledge building practice in a principled way in a class of lower ability Science students. Through the narrative of teacher's planning, enacting and reflecting, we hope to provide a glimpse into 21st century teaching competencies and ways to develop teachers' design capability.

Teachers' role in a KB classroom

KB practice involves teachers making decisions that move towards fostering and sustaining a knowledge creation culture that supports creative work and continual improvement of ideas. Teachers have to think about the kind of interactions in their classes that puts students' ideas at the center of the classroom enterprise (Scardamalia & Bereiter, 2003). Teachers also have to rationalize and translate their teaching practice in relation to Knowledge Building principles (Scardamalia, 2002) which characterize an interactive system that makes continual improvement of ideas possible. Apart from these efforts directly relating to translating KB principles, teachers also have to adapt teaching strategies according to their students' diverse needs and academic backgrounds, and provide students with sufficient guidance to engage their heart and mind in knowledge building processes (So, Seah & Toh-Heng, 2010).

Knowledge building in a science classroom

Many studies have undertaken the task of implementing knowledge building approach in the teaching and learning of science topics. Research has demonstrated that students of all ages can work as knowledge builders, e.g., when students are given opportunities to attempt problems of understanding that they are interested to explore, they are able to work through the problems to derive good explanations. All of which characterises deeper inquiry in science (Zhang et al., 2007; Scardamalia & Bereiter, 2009; Chuy et al., 2010). Although research has shownthat knowledge building pedagogy benefits both high- and low-achieving students (So et al., 2010, Niu & van Aalst, 2005; and Chan & Lee, 2007; So et al., 2010), there still exists a general belief that low ability students do not have the cognitive foundation to navigate in such an environment. This misconception of students' knowledge building ability is generally mirrored in an examination of existing literature on teachers' beliefs, practices, and competencies.

Narratives of teacher reflecting and designing a KB classroom

This case study traced the work of a teacher who has six years of teaching experience and two years of Knowledge Building experience over a 5-week period. He has been working with Normal Technical (NT) classes for all his years as teacher. These NT students are the lowest scoring cohort in the Primary School Leaving Examination and deemed to be less inclined academically. Their secondary education mainly prepares them for further vocational and technical training at the Institute of Technical Education (ITE). Based on his experience with this group of students, the teacher was initially hesitant about adopting KB approach on the topic of "Food Matter" due to time constraints. However, after he discussed the values of science education with his Head of department and the researcher, he decided to try to prioritize the "developing of thinking about science" (as he put it) rather than the delivery of content in his NT class this year. He felt that this goal matched with that of the KB approach.

Getting started

For the first lesson, the teacher started off by sharing some basic knowledge on the topic on Food, followed by a classroom discussion on the topic. The discussion was done solely in class and captured by the teacher on the whiteboard. This brainstorming on "Food" raised some interesting questions such as "how is food important?" and "how is food made/ created?" With knowledge building principles of real ideas and authentic problems in mind, the teacher was careful not to dictate the content so as to allow students' ideas to take precedence in the classroom. He later reflected that he was pleasantly surprised that the students already knew quite a bit in the textbook and that they were able to recall the facts from textbook.

Shaping ideas through experiment and discourse

In the second lesson, the teacher felt that more information was needed to develop his students' ideas about food so he introduced a series of experiments on food testing and got students to talk about these experiments. A student managed to connect starch observed in the experiment to their discussion on 'plant being the largest producer of food' in the previous lesson. The class subsequently became interested in the growth of plants as a source of food producer. This interest led to a discussion on environment when the idea of soil acidity was introduced. Students verbalized their ideas on acidity in soil and the teacher wrote their ideas on the whiteboard. He then got students to take down notes about the discussion in their own journals. Throughout this, teacher actively modeled note-taking and active-listening. He realized, in retrospect, that "the NT students started to ask question that Express students would not ask", he described that as his turning point in the way he was determined to design the lessons the knowledge building way.

Extending discourse in class to include online platform

At this point, the first Knowledge Forum (KF) View was created to get students to pose their ideas online instead of simply voicing them out in class. The transition to the online platform was fairly seamless because students were eager to extend their classroom discussions. Thus, students' ideas came forth quite quickly at this stage.

Figure 1. First Knowledge Forum View for the students

The teacher explained that since KB teaching method is not one size fit all, different teachers have different styles and different classes have different needs. Based on this thought and as he thought through what has taken place in class so far, the teacher decided to get students to move away from textbooks and express their understanding through journal and notes to complement their idea sharing on KF. Further, to make sure that students are motivated to journal their learning, he decided not to provide additional notes to students and instead,

get them to use their own journal for revision. Hence, throughout these lessons, whenever students asked him for teachers' notes, he replied that the textbook is sufficient and that they (the students) should be the ones creating their notes for revision.

Redesigning scaffolds to sustaining idea improvement

In planning the third lesson, the teacher noted that the questions posted by students on KF were not good enough as students didn't understand how to use the scaffolds. He decided to redesign the scaffold to make it more understandable to and accessible by his students. He found a resource online that unpacks the original knowledge building scaffolds into active phrases. For example, this new set of scaffold has four sentence starters; "I think", "I learn", "I know", "I believe", "I saw" versus "My theory" in the original KB scaffold and "I wonder why", "I wonder if", "I wonder who…what…where…how" replacing "I need to understand". The new set of scaffolds seemed to work, but the teacher soon realized that students' questions posted online were quite similar (lack of idea diversity needed for knowledge building). Hence, he decided to give them more time to shape their ideas. He got students to first jot down their ideas in their journals, then read the notes on KF, and subsequently post a different or improved ideas on KF. He also got students to focus on writing meaningful titles for their notes in an effort to get them to think about their post.

In one of the subsequent KF views titled 'Sources of Food - Concepts' (refer to Figure 2 below), students posted notes and built on others' notes while teacher made use of these notes to conduct a class discussion in which students brought up multiple ideas, such as mass production and how cities are made. Students also brought in relevant information on agriculture that they had learned from watching National Geographic.

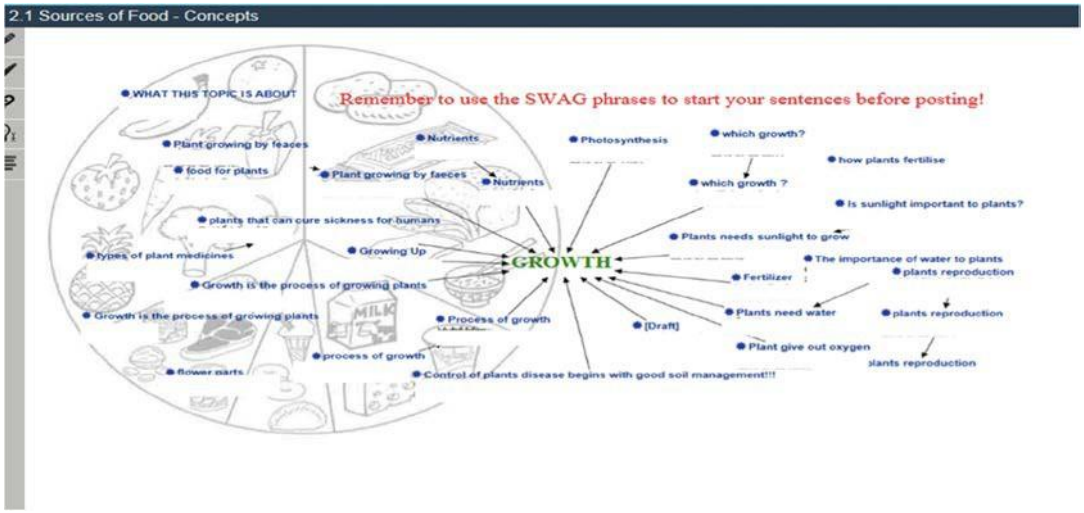

Figure 2. Knowledge Forum view titled Sources of Food– Concepts.

When one student posted, "I wonder how fertilizer helps plant grow faster" and "how do you improve food production", the teacher seized this opportunity to start a class discussion about fertilizer. Students responded with a multitude of perspectives on fertilizers, e.g., a danger to health. He then showed the class two sets of videos as resources for students to watch and deepen their understanding of the points discussed in class.

The teacher felt that there was a deeper understanding of this topic for the students this time round. Students were particularly interested in the video of slash and burn as Singapore was then undergoing a period of haze caused by such actions in Indonesia. The teacher utilised this interest and got students to research online on the two topics (fertilizer and slash and burn) and the question ("how do you improve food production"), and to post their information gathered on a new KF view titled "Soil Fertility".

Embedded assessment

Before the final lesson in this series of KB lessons, the teacher worked with the researcher to design questions based on a new scenario of a group of farmers living near volcanoes and got students coming together to reason out the scenario. Students sat in groups of three to reason out the case in Indonesia where farmers continued to stay close to active volcanoes. Many were quoting what they understood about slash and burn, soil, farmers' needs, etc., to explain the situation. They were also talking about the danger of the lives of farmers as they rationalized the scenario. Upon reflection, the teacher felt that students were displaying critical and global thinking which was quite rare for this group of students, as seen in their past performances. Results from this exercise

showed that the students were able to accurately surface key ideas, pull out information, and even connect information from the various discussions in class and on KF to explain the phenomenon. The explanation might include naive understanding but the teacher reflected that he was surprised at the reasoning the students displayed in their response to the questions which he has not seen before. Below are abstracts of the students' interview.

Student 1:	What if their house is not close, but their plant is close. They cut and harvest and it become(s) the new fertilizer. Some volcano has certain timing. The one in Surabaya, the tour guide told me there is a timing every year.
Student 2:	That maybe the reason because lava is hot, maybe the farmers' plant needs heat. Oh wait! the smoke is carbon dioxide right? So the plant takes in carbon dioxide and take(s) out oxygen.
Student 3:	The ash maybe fertilizer, we take like the slash and burn example, those remaining burn parts become the fertilizer. The burn from the slash and burn.

Rise above

As a final activity, teacher printed all of students' notes in the 'Soil Fertility' view. He got students to review one or two notes each, then put the notes up on the classroom wall to build a collective whole-class learning artefact based on the overarching theme of 'yield'. After the activity had been completed, the teacher led an entire class discussion to get students to connect and synthesize ideas.

Conclusion

The dynamics of a knowledge building classroom is highly dependent on the interaction between teacher and students. In this study, the teacher's role was largely that of providing time and space for students to inquire and explore their ideas on KF, and advancing knowledge along with them. He also carried out the critical task of developing lessons which encouraged inquiry processes and supported collaboration amongst students. His lesson design incorporated a principled way of designing a trigger activity (experiments on food testing and soil acidity), and providing opportunities for contribution (creating new KF views and coming up with scaffolds), as well as space for collaboration (classroom discussions to allow students the opportunity to voice their opinions).

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Appendix A

Wright Brothers' Story (in PPT format)

THE STORY OF THE WRIGHT BROTHERS…
AN IDEA IMPROVEMENT JOURNEY

on *December 17, 1903*, the *Wright brothers (Wilbur and Orville Wright)* made history when their small biplane lifted off a sandy beach in Kitty Hawk, North Carolina!!

Slide 1

What motivated them?

the brothers opened a repair and sales shop in 1892 (the Wright Cycle Exchange, later the Wright Cycle Company) and began manufacturing their own brand in 1896. They used this endeavor to fund their growing interest in flight.

Slide 2

Their intense preoccupation with their airplane was fueled not by economic necessity -- income they already had, from their bicycle business -- but mostly from their *imaginative determination to cross one of the last technological barriers to human flight- stability in the air.*

Figuring out the problem of understanding

The Wright Brothers spent a great deal of time **observing** birds in flight. They noticed that birds soared into the wind and that the air flowing over the curved surface of their wings created lift. Birds change the shape of their wings to turn and maneuver. They believed that they could use this technique to obtain roll control by warping, or changing the shape, of a portion of the wing.

Slide 3:

On the basis of observation, Wilbur concluded that birds changed the angle of the ends of their wings to make their bodies roll right or left. The brothers decided this would also be a good way for a flying machine to turn—to "bank" or "lean" into the turn just like a bird—and just like a person riding a bicycle, an experience with which they were thoroughly familiar. Equally important, they hoped this method would enable recovery when the wind tilted the machine to one side (lateral balance). They puzzled over how to achieve the same effect with man-made wings and eventually discovered wing-warping when Wilbur idly twisted a long inner-tube box at the bicycle shop

Collaborating and working together to get ideas and information

Starting with gliders

Over the next three years, Wilbur and his brother Orville would design a series of gliders

They read about the works of other inventors of hang-gliding flights. They corresponded with other scientists & inventors concerning some of their ideas. They recognized that control of the flying aircraft would be the most crucial and hardest problem to solve.

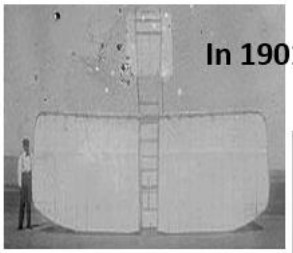
Slide 4

Testing and trying out ideas

In 1900, the Wrights successfully tested their new 50-pound biplane glider with its 17-foot wingspan and wing-warping mechanism at Kitty Hawk, in both unmanned and piloted flights. In fact, it was the first piloted glider. Based upon the results, the Wright Brothers planned to refine the controls and landing gear, and build a bigger glider.

Slide 5

Glider in 1900



In 1901

In 1902

Glider Vital Statistics[24]

	Wingspan	Wing area	Chord	Camber	Aspect ratio	Length	Weight
1900	17 ft 6 in (5.33 m)	165 sq ft (15 m²)	5 ft (2 m)	1/20	3.5:1	11 ft 6 in (3.51 m)	52 lb (24 kg)
1901	22 ft (7 m)	290 sq ft (27 m²)	7 ft (2.1 m)	1/12,*1/19	3:1	14 ft (4.3 m)	98 lb (44 kg)
1902	32 ft 1 in (9.78 m)	305 sq ft (28 m²)	5 ft (1.5 m)	1/20–1/24	6.5:1	17 ft (5.2 m)	112 lb (51 kg)

* (This airfoil caused severe stability problems; the Wrights modified the camber on-site.)

Slide 6

Improving ideas, facing new problems

In 1901, at Kill Devil Hills, North Carolina, the Wright Brothers flew the largest glider ever flown, with a 22-foot wingspan, a weight of nearly 100 pounds and skids for landing. However, many problems occurred: the wings did not have enough lifting power; forward elevator was not effective in controlling the pitch; and the wing-warping mechanism occasionally caused the airplane to spin out of control. In their disappointment, they predicted that man will probably not fly in their lifetime.

Slide 7

Advancing understanding with new experiments

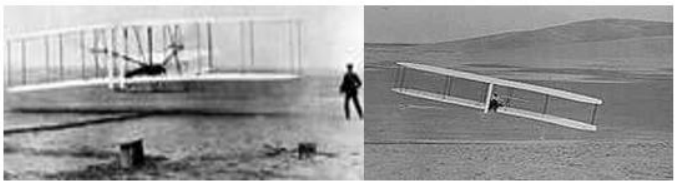
In spite of the problems with their last attempts at flight, the Wrights reviewed their test results and determined that the calculations they had used were not reliable. They decided to build a wind tunnel to test a variety of wing shapes and their effect on lift. Based upon these tests, the inventors had a greater understanding of how an airfoil (wing) works and could calculate with greater accuracy how well a particular wing design would fly. They planned to design a new glider with a 32-foot wingspan and a tail to help stabilize it.

Slide 8

Continual improvement of ideas through redesigning and more testing

Inventing the Flyer

During 1902, After months of studying how propellers work the Wright Brothers designed a motor and a new aircraft sturdy enough to accommodate the motor's weight and vibrations. The craft weighed 700 pounds and came to be known as the Flyer.



Slide 9:

The brothers flew numerous test glides using their new glider. Their studies showed that a movable tail would help balance the craft and the Wright Brothers connected a movable tail to the wing-warping wires to coordinate turns. With successful glides to verify their wind tunnel tests, the inventors planned to build a powered aircraft.

Solving more problems…deepening understanding

Wright Brothers - First Manned Flight

The most successful, powered, piloted flight in history…but the Wright Brothers didn't stop here.

Slide 10:

This was the first successful, powered, piloted flight in history. In 1904, the first flight lasting more than five minutes took place on November 9. The Flyer II was flown by Wilbur Wright.

More set back

- In 1908, passenger flight took a turn for the worse when the first fatal air crash occurred on September 17. Orville Wright was piloting the plane. Orville Wright survived the crash, but his passenger, Signal Corps Lieutenant Thomas Selfridge, did not.

Slide 11

But with more advancement as well…

In 1911, the Wrights' Vin Fiz was the first airplane to cross the United States. The flight took 84 days, stopping 70 times. It crash-landed so many times that little of its original building materials were still on the plane when it arrived in California. The Vin Fiz was named after a grape soda made by the Armour Packing Company.

Slide 12

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Slide 13

Appendix B

Idea Cards

I NEED TO UNDERSTAND

MY IDEA

New information I found:

TESTING MY IDEA

Appendix C

Students' Idea Worksheet

Exercise 1: Think card (Experimenting)

Write down your idea about the experiment on ……..

My idea
What I need to find out to make my idea better

Transfer these ideas onto Knowledge Forum when you next get to work on computer.

Ideas from Experiments

Some help for writing your ideas…

a. Observe the experiment carefully, ask yourself what really happened.
b. Then write down why you think it happened

In the experiment I saw ……. (what it looked like) I think it is because ……. (explaining why you think it happened).

Exercise 2: How do scientists work?

Reflection as a scientist

What do you think a scientist need to do to inquire about ……..?

How do you think a scientist might do to find out more about the experiment?

Exercise 3: Pulling together ideas in your group

Idea from:	Question from:	Information from:
Member #1:		
Member #2:		
Member #3:		
The main ideas I have learnt from my friends are:		
We now need to understand……		

Exercise 3: Some help for pulling ideas together…

1. Read all the ideas, questions and information. This is important to read your friends' idea carefully so you know how they can help you improve your ideas.
2. Next compare the ideas:
    a. Are they the same? If they are, don't write them down, they show through in your individual idea box.
    b. Are they different? Different ideas are important to help you improve your ideas.
        i. Do you agree with that particular idea?
        ii. Do you think you can find evidence to support that idea?
        iii. Do you agree with the explanation of the idea?

Exercise 3 (For teacher): An example of the table above:

Idea from:	Question from:	Information from:
Member #1: how do we test which part of the compass is made up of magnet?	Can magnet be used to make compass?	I think if we hang a magnet next to the compass we should be able to find out.
Member #2:is magnet used for the whole compass?	I wonder how magnet can be used in our daily life?	I know fridge magnet must have magnet in them.
Member #3:magnet can be used to make compass because the north seeking pole will always point to the north pole and the south seeking pole will always point to the south	I wonder why the compasses' needles keep moving spinning when we bring them close to the magnet	North seeking pole will point to north and south seeking pole will point to south
Member #4: I think magnet is made of water	I wonder if magnet will dissolve in water.	

The main ideas I have learnt from my friends are:

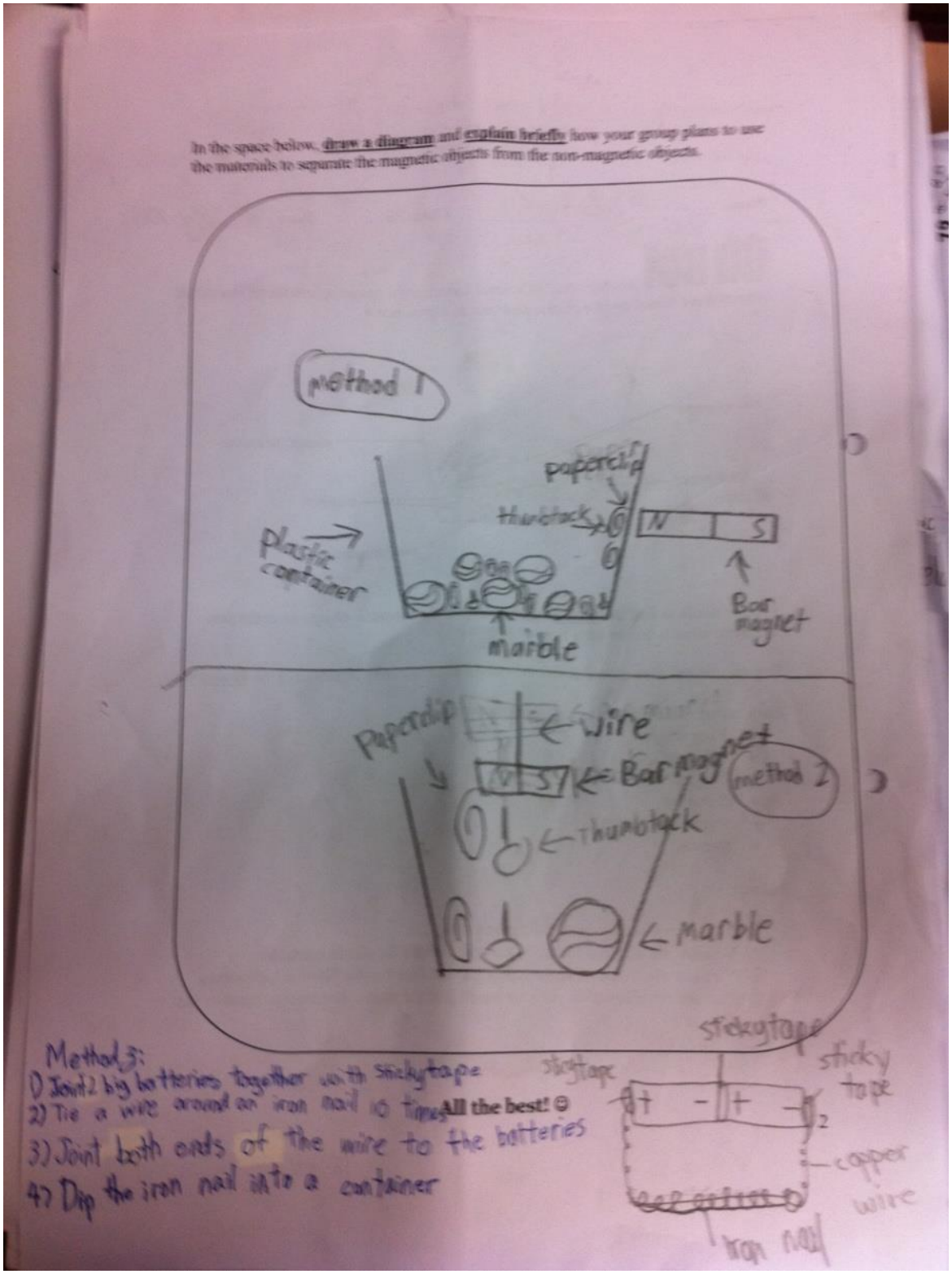
"I have learnt from john that compass is made of magnet but I never asked about what part of compass has magnet in it. I have learnt about the north seeking pole and south seeking pole in the magnet but I don't know what each pole do. I did not write down Mary's idea because I do not think it is possible.

We now need to understand……

We should try out which part of compass has magnet. Can hang them together.

Exercise 4: Planning research to improve collective ideas/seek explanation for collective questions

(For teachers) Example of a students' planned experiment:

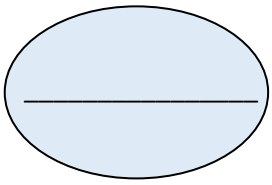


Exercise 5: Group mindmap (working towards pulling ideas together and improving ideas)

(i) Map out the key ideas in your group about '……' (The kb problem)

(ii) Connect these key ideas

(iii) Explain each connections



Appendix D

Sample data interpretation/analysis of students' notes

Students' notes from KF	Data Interpretation/ Discourse Analysis
why did the water not freeze. by ashrinamajitha s. [2012, Feb 13] My Theory is that i think the bottle of water did not freeze because the mineral water contains minerals which makes it impure and decreases the freezing point. the bottle also did not freeze maybe because the atmosphere in the fridge and the water in the bottle is the same temperature, therefore it froze only after it was removed from the fridge.	A. Generating Questions Explanatory statement
Its pure water by faisal s. [2012, Feb 13] Its distilled water and its pure, it has fixed boiling and melting point	Explanatory Statement /Information sharing
too low to freeze ? by kaiping l., isaac s., isaac s. [2012, Feb 13] I need to understand is the temperature is too low to freeze.	Puzzlement
Can freeze below -40 degrees by songcuan j. [2012, Jun 27] New information; Scientists have tested freezing water below the temperatures of -40 degrees Celcius, the average temperature existent in the Northern Hemisphere. It was successful for every experiment, both with impure and pure water.	Information Sharing/Linear Treatment of Information
-40 degrees Celcius water by Mrs Toh w. [2012, Mar 04] Does this mean that there is supercooled (pure & impure) water at -40 degrees Celcius? Wow! Which is the source of this information please, John? I'd like to read up more :)	Clarification of Source of Information
Kinetic particle theory by marcus l., yachna b., tessa n., linrun z., tessa n., yachna b., linrun z. [2012, Feb 13] My Theory is that it is because the water in the bottle is already below -2 degree celsius which should actually be in solid state whereby the particles loses energy ,so when it touches the ice which is at around 0 degree celsius , it tries to reach the temperature of the ice , therefore when a substance with a higher temperature touches a	B. Identification of relationships Explanatory Statement

substances with a lower temperature , it started to lose energy and condense into solid state. Here's how it's happened by faisal s., minhhieu d., yujie l., yi c., yujie l., yi c., minhhieu d. [2012, Feb 13] My Theory is because the bottles were tightly closed so the cold air could not go inside the bottle and froze the water from liquid to solid. The water froze when because the water was already cold and when it touched the ice it turned into ice immediately.	Elaboration of the problem
MAKE SUPER COOL WATER!!! by yiling t. [2012, Feb 13] The water is still liquid below melting point because when you put 4 bottles inside the freezer of -20 degree celcius, the energy is divided into 4 bottles. Therefore, after 2 hours, the bottle nearer to the freezer will be frozen while the rest will still be in liquid form as they haven't lost enough energy to turn into solid. When the bottles are taken out and is poured into the ice cube, it will turned into solid as the ice cube gain energy from the liquid that is poured onto it enabling the liquid to turn into solid ice directly. But there will be some liquid left as not all the liquid turned into solid. Only some part of the liquid turned into solid ice.	Postulating a theory
How does pressure affect the diffusion rate of molecules. by brendon w. [2012, Feb 18] When pressure is being applied to molecules, it affects the rate of diffusion. Pressure imparts energy to the molecules thus making it move at a faster rate. This causes the moelcules to collide with one another, causing it to gain more energy too. It also might cause the temperature of a molecule to increase when it is being heated.	New Problem/ Information Sharing [linear treatment]
new information by brendon w. [2012, Jun 27] So i tried doing this experiment after my science lesson to try and see if i would get the same results as shown in the video. Sadly, i received negative results. Items used for the experiment: 4 bottles of mineral water. the fridge. a glass bowl. So basically, I bought four bottles of water from 7-eleven. I placed all of	Testing of theory

them into the freezer for 3 hours. I was not too sure about the temperature of the freezer at that time as I didn't know where to look. After 3 hours, I took out all the bottles and found that none of them froze. Thus, I could not carry out the rest of the experiment. I hadn't have the time to do this several times due to the time constrain I had. So in conclusion, the reason behind the failure of the experiment might have been due to the temperature of the freezer. Putting this aside, I had this theory during the lesson when our teacher asked us to think of the reason behind the results of the experiment shown during the class. My theory was that the water might have been too pure thus, it was not able to freeze. This is because liquid would need to have that nuclear reaction with some other un-pure particle like a simple tiny dust particle or some dirt in order for the water to change its molecular state. Another theory I had was that the movement of molecules was being slowed down to the extent that they seem to not be changing state at all. This theory is related to absolute zero theory where the surrounding temperature is that cold to the extent that things seem not to move at all. I really hope to find the reason behind this results received in the experiment. Hopefully I'll find out soon.	Emergent Problem Reflection /Theorising Theorising