A Practitioner's Insight on Grade 5 Pupils developing and improving theory in the topic of cells.

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Abstract: Knowledge Building has been defined as "the production and continual improvement of ideas of value to a community, through means that enable the community to accomplish more than the sum of individual's contribution" (Scardamalia & Bereiter, 2014). The theoretical concept and research findings have been extremely forthcoming. The question remained that of "What do these abstract definitions of knowledge creation trajectories look like in a classroom?". It has been talked about in educational research in the past decades, but the concept of the idea-centric classroom has remained elusive to many teachers. In this study, we describe an effort to clarify this 'elusive' practice by developing practice-based knowledge about the trajectories of knowledge-building activities and outcomes through a practitioner's reflection and recount. The process of idea generation; theory improvement through pupils' scientific reasoning is described through the reflection of the practitioner. This practitioner has two years of KB experience embedded within six years of teaching experience. The discussion of this narration aims to provide insights into (i) teacher's curriculum knowledge to support the knowledge building practice; (ii) teacher's interpretation of the cognitive and social practices needed for pupils to improve theories. The paper also highlights the seized and missed opportunities of a principle-based approach to lesson design.

Introduction

Knowledge building pedagogy is a principle-based approach to learning that has a goal of co-creating "new" perspectives or understanding advanced knowledge beyond just the limit of an individual, it is a collective effort to explore and learn more about the topic. This case study describes a practitioner's (second year of knowledge building work but with six years of teaching experience) recount and reflection of a series of 4 one-hour lessons Knowledge Building (KB) lesson she designed and enacted. These lessons spanned over three weeks. The teacher worked with 26 high-progress pupils in this particular class. She was keen to explore the possibilities of using Knowledge Forum (KF) to start a new topic on Cells with all the current constraints of time, curriculum and assessment demand. She started with a problem of understanding for her practice "I would like to find out how the KB approach in the classroom really impact pupils' learning in Science?" Her focus was on getting pupils to improve their theories on "cells" to bring about deeper learning. A set of curriculum mapping (connections across facts, concepts, and theories in the topic of cells) was put together at the teachers' weekly meeting to understand the teacher's perspectives and her take on the content required in the curriculum document.

The teacher's reflection, lesson design and enactment were recorded. In this paper, we will discuss the areas of (i) content to be covered; (ii) activities designed; (iii) thinking scaffold adopted; (iv) point of interest or worthy ideas picked up by teachers, strategies to recognise patterns in pupils discussions to highlight misconceptions; (v) pupils' outcomes; in each phase of her lessons (see Appendix A). All pupils' discourses are recorded on Knowledge Forum. In this reflection, the teacher also systematically analysed the notes from her lesson to identify key points of interest to be addressed in her next lesson. We also coded 226 of her pupils' notes in two KF views for (i) quality of questions and (ii) quality of explanation after each iteration to inform her of her pupils' knowledge building trajectory and learning.

Teachers' understanding of content and curriculum as captured by a collaborative curriculum map

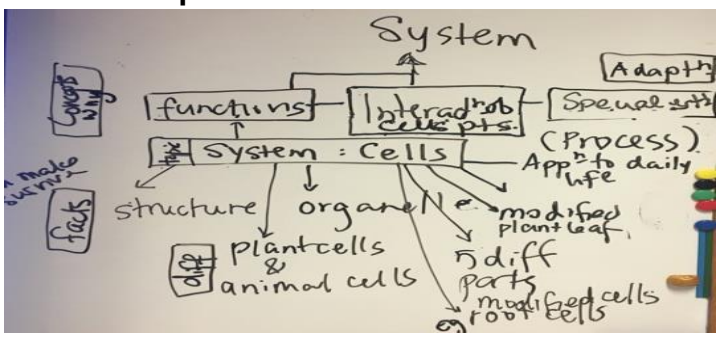

Figure 1. Unpacking the facts, concepts and theories in curriculum on the topic of 'cells'.

Using the knowledge structure of facts, concepts, theories (Erickson, 2006), the teacher with her KB teammates mapped out the curriculum demand of cells (see Figure 1). The concepts identified by the teachers were 'adaptation, specialisation and functions of cells, 'interactions of cell parts". The teachers found it difficult to decide if functions of cells should be a fact to be learned or a concept to be understood. They, nevertheless, decided to place it under concepts, rationalising the fact the pupils need to know the individual functions of the cell parts, then compare and contrast them to derive a common understanding of the overall functions.

Lesson 1: Figuring out pupils' problem of understanding: Idea generation using KF scaffold

The teacher started the series of lesson with a KWL activity (what I know/what I want to know/ what I learned) with a rationale of wanting to use what her pupils "do not know" to guide her lesson (see Figure 2). This lesson on "What is a cell?" was conducted over 2 periods (1 hour) in a single seating during curriculum time. The pupils had their one-to-one computing device to facilitate the use of KB during the lesson.

> "My approach was to simply ask a question "What is a cell?" without giving any clue such that it would tease out pupils' initial conception and ideas of what a cell was. I did not dictate what the pupils should know. Instead, I wish to know what the pupils do not know as that would better guide me to craft my KB lesson design."

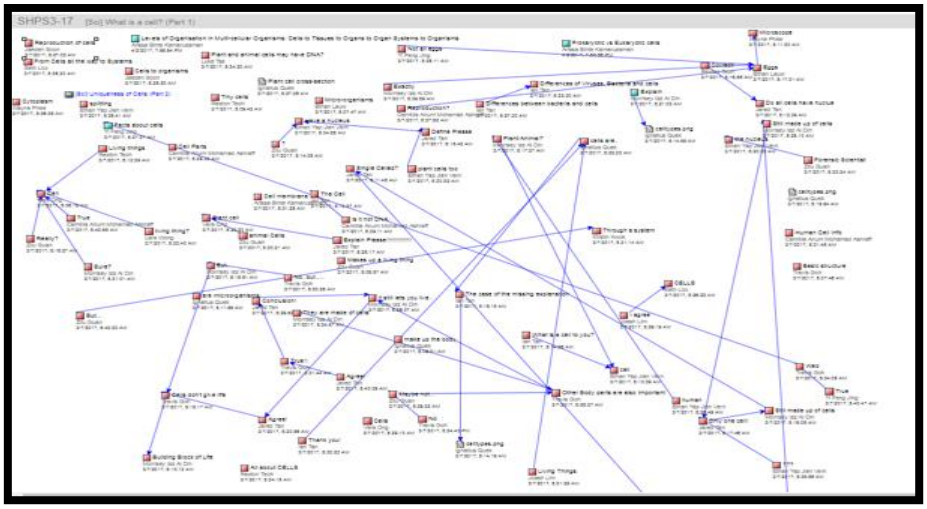

Figure 2. First Knowledge Forum view where pupils posted questions and ideas about cells in a KWL activity.

The teacher studied the notes carefully and concluded that the pupils could state that there were different cell types such as egg cell, bacteria cell, plant cell but she identified the following gap.

> "However, they were not sure which cell had a nucleus. Using their discussions and questions, I thought it was timely to post differences between plant vs animal cells to narrow down to these two cells that they were bouncing ideas about and seemingly asking…"

She then picked out the following post, "Is this cell a plant or animal cell?" that inspired her for her second lesson on differences between plant and animal cells. She also identified the following notes that defined pupils' misconceptions that needed to be addressed quickly.

> "…pupils mentioned that only animal cells had a nucleus which is a misconception and it was important for me to ensure that this was clarified by the next lesson."

She reflected that the lesson gave her insights to the many variations of ideas pupils had about cells and framed a key context for her next lesson. She was also intrigued by a question from a pupil (see Figure 3) who was able to question beyond the structure and appearance of a cell "What is really a cell? You have shown the structure, not what a cell itself is". With this understanding of her pupils' ideas, she was convinced that she should consider alternative cascading "chains" (leading ideas) that could serve as potential pointers for discussion in the next lesson.

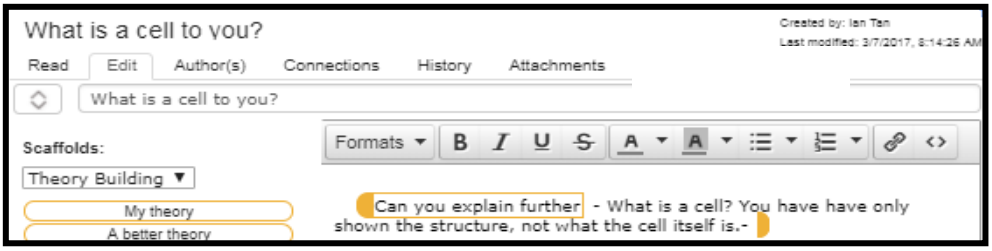

Figure 3. Pupil's responding to the question of "What is a cell?" by going beyond the structure of the cell.

Lesson 2: Uniqueness of cell (Customized cell scaffold)

This second lesson was focused on pupils differentiating plant and animal cells as that addressed pupils' vague understanding about cells and the cell parts in the first lesson.

> "I had pupils to use the customised scaffolds to build ideas that were more interconnected with one another and to particularly focus their attention to using key concept related words."

Two pedagogical moves by teacher to allow more independent inquiry from pupils

Customised scaffolds (e.g. the cell is different from the other cell because…; this part is important because…) were designed and adopted for pupils to initiate and lead discussions spontaneously. The teacher felt that her original generic scaffolds in KF were rather abstract for her pupils and she wanted to contextualise the scaffolds to a more familiar context for her pupils, i.e. the context of cells.

The teacher decided to provide two images to pupils. Instead of directly telling pupils to list out differences between plant and animal cells, the term 'unique' was used and unpacked using the scaffolds which were customised for them to ideate anything they knew about the cell parts.

> "In lesson 2, these pictures specific type of cell, e.g. (see Figure. 4) were posted intentionally but pupils were not informed that they were the human cheek cell and hydrilla leaf cell. However, they were told that the cell on the left was an animal cell and the right was a plant cell. Using this, they had to come up with evidences to support their reasoning. The visual stimulus should help them differentiate that the green cells on the right were plant cells as they had chlorophyll in them and were greener than the cell on the left."

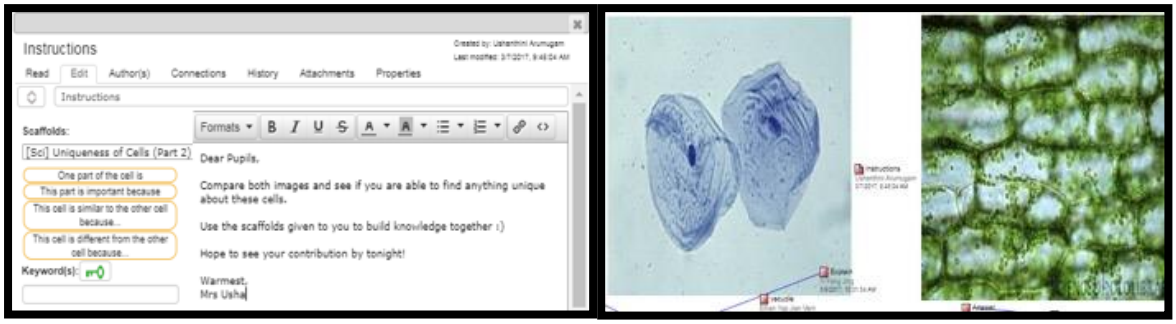

Figure 4. Visualisation to get pupils to think deeper into the differences of plant and animal cells.

She observed that the pupils were building on ideas and were making connections from ideas and that was the initial start for scientific concept building. This is also triangulated with the analysis discussed in result section in this paper. As can be seen in result section, pupils' reasoning of ideas has improved from Lesson 1 to Lesson 2.

It was also in this second lesson that the teacher recognised a pattern in pupils' post on KB that led her to identify some 'islands of discussions' (see Figure 5) that highlighted interesting ideas as well as misconceptions on the topic. This was a new strategy discovered to help her to focus and navigate through the multitude of posts made on KB which could be overwhelming.

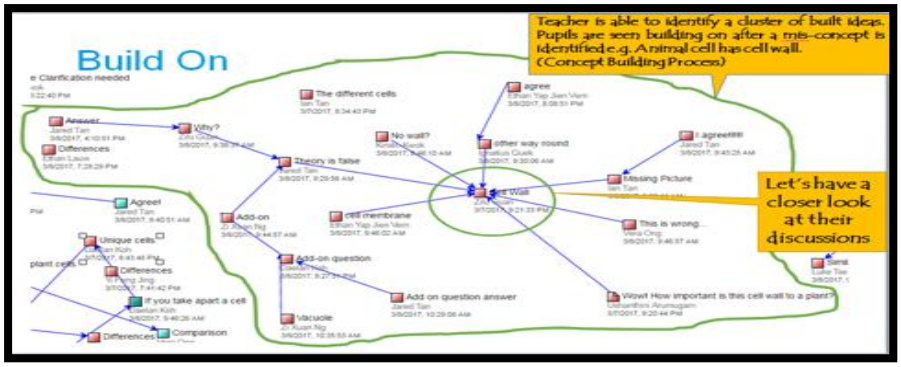

Figure 5. Discussion thread identified by teachers.

Discussion thread 1: Interesting ideas identified:

Note 1: "the plant cells are greener so I assumed that the plant cells have chlorophyll in them."
Note 2: "<The cell is different from the other cell because> the plant cells are arranged in a structure but the animal cells have no structure. Maybe since the animal cells are irregular, they cannot fit together to make a structure."
Note 3: "…there are only plant cells and animal cells"
Note 3: "<The part is important because" are you sure that there are only 2 types of cells? Perhaps there are more types of cells, like bacteria and fungi cells? Perhaps there are more, Right?"

Discussion thread 2: Teacher identified misconceptions:

"One pupil had mentioned that an animal cell had a cell wall but a plant cell did not have a cell wall. This post attracted such attention that many pupils started raising flags and cited evidences to prove with explanations that it was indeed the converse. There were many arrows pointing to this post and that triggered me to take a look at their point of discussion. What amazed me was that pupils whom were quietest started correcting their peers online. It was instant success, as immediate peer-review and engaged learning was taking place spontaneously."

In addition to the concepts and content, the teacher started to notice a shift in pupils' learning patterns, e.g. weaker pupils speaking:

"I was attracted to this pool of discussion as I also noted one of my weaker learners contributing and making his stand...The discussion was getting richer and I noted that pupils were unlearning their misconceptions , relearning and re-teaching one another. "Pupils also clarified about the presence of nucleus in both animal and plant cells which they were unclear in lesson 1. Pupil L's comments captured were able to also add on the differences of both cells. Hence, at this point I had to intervene and use this lesson as a dipstick to address and clarify misconceptions. Before lesson ended, a consolidation was done on the functions of cell parts as they started mentioning about vacuole, cell wall, cytoplasm and the characteristics of plant cell and animal cell."

Lesson 3: Developing Promising Ideas through Constructing Analogy

"This was the post from pupil R which guided me in my lesson design for Lesson 3. This post also further inspired me to think of pupils existing conception." "They only thought 2 types of cells existed. Hence, it was important for me to also address other types of plant cells which were irregularly shaped and address another misconception that highlighted that all plant cells had chloroplasts." (Pupil's note on KF)

Teacher also noticed that pupils were starting to work with and improve each other's ideas. E.g. Teacher highlighted a series of pupil questions based on another pupils' idea, "All plants have chloroplast within their cells", and she went on further to support her 'better theory' with reasoning.

Now that she was confident of the pupils learning different parts of the cell, she tasked them to do an analogy of a cell in a real world context. E.g. A cell is like a castle. This analogy task was a fun and engaging assessment of learning aimed at allowing pupils to demonstrate their learning from the knowledge building process.

Pupils posted their analogies on KF and they had to choose and justify who had the most promising idea. The criteria for "promising" was that the idea had the potential to lead the community to a better understanding of the nature of cells .

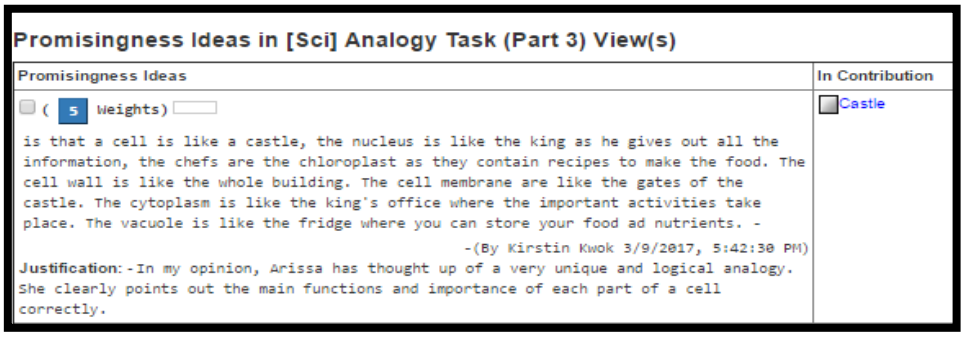

Figure 6. Pupil selects a promising idea and justify their selection

Lesson 4: Building on pupil's ideas to conclude "*perhaps there are more than 2 types of cells*"

This fourth lesson focused on getting pupils to apply the fundamental concepts to new contexts through exploring an unfamiliar context, the Euglena[1]. Teacher reflected,

> "The inspiration for the Euglena question came about when I noted pupils listing a cell that featured both characteristics of a plant and animal cell. As a pupil mentioned, 'What if there were cells that had both characteristics?". Also using pupils' misconceptions raised in Lesson 2, that there were only 2 types of cells, I was determined to show them that there were more than these 2 types of cells in the real-world context. Hence, this could be an avenue to create an awareness amongst pupils about cells that were not made up of just 2 cell types.

Findings: Impact on pupils' knowledge building activities

106 notes from the earlier KF view on "uniqueness of cell" and 110 notes from the latter view on "Euglena" were analysed for the quality of questions and explanation. The following graph shows difference in the number of notes from the two views (see Figure 7). The pupils are clearly thinking in a more complex way as the lessons progressed as they were found to be writing notes that indicate a certain level of analysis (ideas include synthesis and analysis of facts) and synthesis (connecting ideas) in the notes on the latter view.

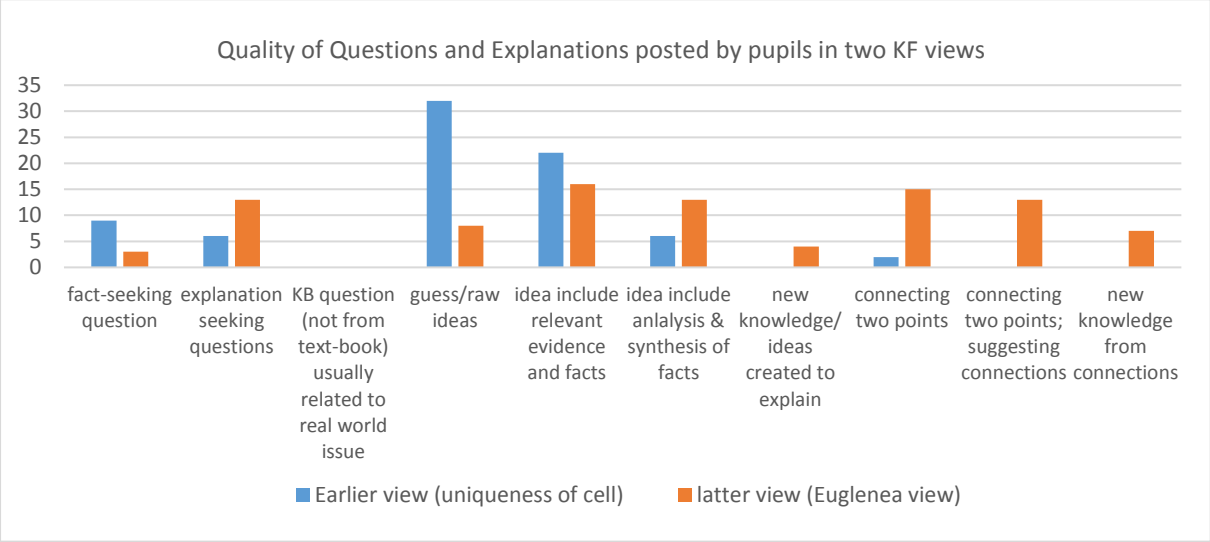

Figure 7. Quality of Questions and Explanations posted by pupils in two KF views

Discussion: Seized and missed opportunities from teachers' observations, pupils' reflection and theoretical perspectives

Seized and missed opportunities from the pupils' perspective

Many of them reflected positively on the collaborative learning on the topic of cells as seen from the reflection written by the pupils. They felt that the use of *KF*

> "helped us to collaborate and learn more about the topic on cells as we collaborated together. We learnt a lot together, learning from each other helped us correct our misconceptions..."

The viewing and providing feedback to one another was also much valued but pupils did not seem to be using the knowledge building language of build-on, theory building, rise-above which was alright as they were accurate in their reasoning with these different knowledge probing elevators.

Seized opportunities from the teacher's perspective

> "KF has given me greater insights into my pupils' understanding of the topic. It has enabled me to adapt my content according to my pupils' learning needs and enrich their learning potential. Having each pupil's response captured enables even the weakest and quietest to make a strong point via the scaffolds. As a teacher, I do not need to mark through a set of pre-assessment task to pitch the learning foreground. The questions raised by the pupils allow me to structure lessons such that fundamental concepts they are weak in are discussed and assessed before moving onto the advanced content."

> "KF has definitely provided a good platform for pupils to tease out misconceptions in science and getting peer-reviews to correct their concepts. With the usage of knowledge building pedagogy, I have empowered the children to own their discussions and learning in a student-centric environment where they were highly engaged."

Missed opportunities

In our effort to trace the teacher's work, we realised that the teacher did not capitalise upon the opportunities for scaffolding their pupils' learning from the misconceptions surfaced. The misconception was corrected rather than worked on like a promising idea or a point of interest. We have since developed a KB pedagogical frame to support teachers in navigating such lesson design and we hope to use a similar frame to analyse more case studies to develop a more generalised practice-knowledge to support teachers in knowledge building practice.

Conclusion

KB not only brings about deeper learning in science, this idea-centric approach is also transferable to other subjects whereby pupils are able to build knowledge seamlessly with one another. With the Knowledge building frame, we were able to bridge theory and practice to successfully engage, enliven and enrich pupils' learning which brings about the joy of learning in science. Teaching and learning has also been value-added by the usage of KB which has been applied in the English Language and Social Studies lessons at Saint Hilda's Primary School.

Endnote

(1) Euglena is a protist which has both the characteristics of a plant and animal cell.

References

Scardamalia, M., & Bereiter, C. (2014). Knowledge building and knowledge creation: Theory, pedagogy, and technology. *Cambridge handbook of the learning sciences*, 397-417.

Erickson, H. L. (Ed.). 2006. Concept-based curriculum and instruction for the thinking classroom. Corwin press.