Using Knowledge Building Technology In Promoting SDL/Col In The Teaching Of Science

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Abstract

The study investigated the effects of using students' ideas on self-directed learning (SDL) and collaborative learning (CoL). Since the announcement by the Ministry of Education (MOE) in 2009 of a new framework to achieve the desired outcomes of education for 21st century learners, schools have made concerted effort to align their teaching and learning to the new initiative.

The intervention used in this study was based on the two principles of Knowledge Building (KB); 1) Diversity of Ideas and 2) Improvable Ideas, proposed by Scardamalia (2002). Students' ideas formed the basis for student interaction. The ideas generated by students were captured using an ICT tool, Knowledge Forum (KF). Three cycles of KB lessons were carried out with a primary 5 class of mixed-abilities students.

The results showed that my classroom practice in using KB as an approach to teaching Science enhanced students' engagement, and increased their motivation to learn. The use of KF promoted self-directed learning and collaboration among students. Analysis of two science topics, 'Heart Organ' and 'Human Reproductive System', showed that the number of notes posted by students on the KF platform increased from 44 to 216, network density on reading (these notes) increased from 8.53% to 45.97% and network density on building onto others' notes increased from 1.99% to 12.07%. Experimental class' academic performance improved more compared to control class from CA1 (Term) to SA1 (Term 2) to CA2 (Term 3) with standard mean deviation increasing from 0.09 to 0.45 to 0.55.

Rationale

In my urgency to use ICT tools to promote the SDL and CoL in my classroom teaching, I experimented with a number of web 2.0 tools. I walked away, feeling frustrated because I was not certain how these ad-hoc tools lent to achieving my intended goal even though my students demonstrated engagement during lesson which lasted as long as the period the tool was used.

Since 2009, I have been searching for an ideal ICT tool which could support teaching and learning in the classroom with a focus on students' learning through collaboration and with assessment feature within the tool to measure a self-directed learning process. I have come across and used some of the web 2.0 tools, such as Edmodo, Google Sites embedded with Cover-It-Live, Google Docs, Linoit, Popplet Vocaroo and Wall-Wishers to achieve my intended goal. The tool that best served my needs was the use of Google Sites with embedded web 2.0 tools. However, it was time-consuming to create and maintain a site and it lacked an assessment feature which I could measure and assess my students' collaborative participation. Another major problem was its lack of appeal to teachers who were not IT-savvy and its affordance for both teachers and students was low with steep learning curve when new tools were being introduced. This solution was lop-sided with the tilt towards using technology more than acquiring and enhancing pedagogical practice to affect students' learning. I needed a pedagogical approach to transform the way I teach Science and an ICT platform to capture the process and progress of my students' learning with provision of assessment tools to help me understand how well my students were developing their SDL and CoL skills.

A quick verbal discussion with a few science teachers in my school revealed that their teaching practices in the classrooms generally started with a trigger (a question, video clip or picture) to gather responses from students who volunteered. These responses were shared as a class and the teacher took note, usually mentally, of responses which were incorrect or presented as an alternative conception to the intended learning outcomes. What followed was the actual teaching using either prescribed PowerPoint slides produced by the publishers or self-customised slides created by the teachers. The subsequent lesson might be a laboratory experiment, guided by an activity workbook, which was again prescribed by the publisher of the textbook, in which students went about the process of carrying out an experiment, only to arrive at the conclusion of an existing proven theory which students likely would have already known from reading the textbook. With this approach to teaching, there was little opportunity for students to interact, exchange ideas and learn from one another. Even for group work, students interacted with at most four or five members within a group, and teachers were still exercising much control over the flow of the activities of the students.

Based on my personal teaching experience in which I had taught both high-progress and low-progress students over the years, this general approach to teaching science was well and good for students who were already performing well in science and were generally self-motivated. However, for students who were academically weak in the subject, this mixture of didactic and cooperative learning approach did not help them to retain the knowledge learnt for even a day. Another problem with using this mixed approach was that not every student was engaged during lessons and only a handful would volunteer responses when a teacher posed a question; not every student's idea was heard or expressed.

As a teacher, I was committed to incorporate the learning of SDL and CoL skills for my students during my lessons. Being a pragmatic teacher, I needed to balance the constraint of time, which consisted of only 5 periods (two and half hours) a week for Science teaching, using ICT effectively, promote acquisition of the SDL and CoL skills and complete the syllabus on time in order that my students were prepared to sit for their examinations. In this study, I examined my classroom practices in promoting SDL and CoL skills in and among students and analysed of the social network of students reading and building-on patterns in the KF platform.

This study aimed to answer the following questions:

(1) Does the use of KB pedagogy enable students to be self-directed and collaborative in their learning?

(2) What is the impact of KB pedagogy on students' academic performance?

Literature Review

Oshima et al (2006) mentioned two different perspectives of learning; an acquisition and participation metaphor. Early cognitive constructivists, Piaget (1967) and Vygotsky (1978), postulated that knowledge is constructed when learner is confronted (through interaction with peers or with the expert other) with information that 'does not agree' with his current understanding of the piece of information and cognitively acts to situate the new piece of information by modifying current knowledge. Knowledge is assimilated when there is a dissonance between prior and current knowledge. Social constructivists, influenced by the early works of Piaget (1967) and Vygotsky (1978), suggested that learners construct their own knowledge within a social context and assimilation of knowledge occurs at the individual level. In this view, learning is characterised by acts of constructing knowledge and the acquisition of it. The researchers defined the participation metaphor as 'learning as a process of participation in cultural practices and shared learning activities'. The focus of the metaphor is therefore on activities of ''knowing'' rather than ''knowledge'' as a product. Paavola, Lipponen, & Hakkarainen (2004) proposed a third learning metaphor; knowledge creation metaphor, different from the previous two but focuses on creation of new knowledge based on given knowledge.

Holmes, FitzGibbon, Mehan, Savage and Tangney (2001) wrote:

> Learning is seen as a social and collaborative activity that is facilitated rather than taught by the teacher. Building on constructivist theories, where students are involved in building their own knowledge, social constructivism adds an interactive dimension.

Scardamalia and Bereiter (2006) went a little further and postulated that 'knowledge in a field does not merely accumulate but advances … ideas at its leading edge'. Thus, the social context in which learners access, accumulate, assimilate, and advance their knowledge is crucial and it leads learners to form a learning community where everyone learns from one another. An effective social setting, facilitated by an effective teacher, promotes acquisition of self-directed and collaborative attitudes towards learning. This community forms the basis for collaboration among learners to take place. In this community, the learners put forth their individual ideas (opinions, facts and questions), as 'notes', onto KF, every member commits to read all notes and voluntarily provides either more information, resource, explanations or questions to seek clarification or pursue new inquiries. In this manner of sharing and exchanging ideas, learners have access to new information, resources, answers to their questions through their peers and such exchange of information occurs at lightning speed, leading to an improvement of the original ideas. The role of the teacher becomes that of a facilitator and not a 'knowledge dispenser'. Within a knowledge community, collaboration is a natural process and the sustainability of it stems from learners' sense of ownership of their own ideas and brings forth a primitive sense of responsibility to continually put forth worthy ideas and improve on their original ideas after having read peers' responses. This primitive sense of responsibility drives learners to seek out more information to in turn help their peers in improving their own ideas. Through continual improvement of ideas in this collaborative space, more coherent and sophisticated concepts are formed.

Learners, who are traditionally exposed to passive learning from didactic teaching, may feel the tension in the new instructional approach using their ideas to start lessons. Learners come with unique background, prior experiences, personality, idiosyncrasies, and disposition which the teacher must take into consideration in order to design an effective environment for self-directed and collaborative learning to take place. Bereiter, C., & And, O. (1997), in their research, showed that six-graders were very capable in postulating theories in improving over the old ones. Using the then KF platform, these students wrote in their reflection journals on their learning journey within their committed learning community and stated their what they had learnt from the discourse on the platform. They were passionate about conducting research and helping fellow classmates to find answers to their queries. In this process, they showed compassion towards the each other. Immersing learners in this novel way of learning requires the teacher to set ground rules for engagement during paired, grouped or whole class discussion (Raidal & Volet, 2009).

If a teacher's pedagogy is measured on a continuum of progression, at one extreme end is teacher-centred teaching while at the other extreme end is idea-centred, then student-centred teaching is placed nearer towards the idea-centred teaching. KB pedagogy is an innovative way to teach and it moves the teacher along the progress path of pedagogy from teacher-centred to student-centred and to the 'highest form' of teaching – idea-centred teaching. Creating an idea-centred classroom assumes the teacher to possess strong content knowledge and to have overcome the resistance or even fear of placing the control of learning into the hands of her students. Learning in an idea-centred setting requires students to accept that their teacher is not providing any answers and they have to proactively acquire the knowledge through their interaction with their peers and research. This places both teacher and students out of their comfort zone.

Knowledge Building pedagogy has an ICT companion, Knowledge Forum (KF) tool (Scardamalia & Bereiter, 2006). It captures learners' ideas and makes these ideas visible and accessible for all. The tool has six scaffolds which guide the learner on how his ideas are presented when interacting with the others: 1) My theory (an idea which could be a fact, opinion or explanation), 2) I need to understand (posing a question or problem of understanding, 3) New information (new idea from other sources or peers), 4) This theory does not explain (to disagree with someone's theory by testing his theory in a new situation), 5) A better theory (proposing a more refined theory) and 6) Putting our knowledge together.

Description of Study

Intervention was carried out on a class of mixed-abilities students at the primary 5 level. KB was applied during the Term 1 and Term 3 science lessons on 'Heart Organ' and 'Human Reproductive System' respectively. The students went onto KF and worked on their ideas and data was generated using the assessment features, Contribution and Social Network, embedded in KF. In Term 2, KB lessons were conducted but without the use of KF tool.

At the start of the term, I used a social network platform, a web 2.0 tool, to gather information on what my students attributed their failure or success in examination to and their thoughts on whether intelligence was a fixed entity as predetermined from birth. The objective was to understand my students' self-efficacy, (Figures 1 and 2), defined as the self-belief on 'one's ability to influence events that affect his or her lives' which would bear an impact on their motivation to learn (Bandura, 1996 & 1997).

Figure 1. Students' attribution to success or failure in examination / tests.

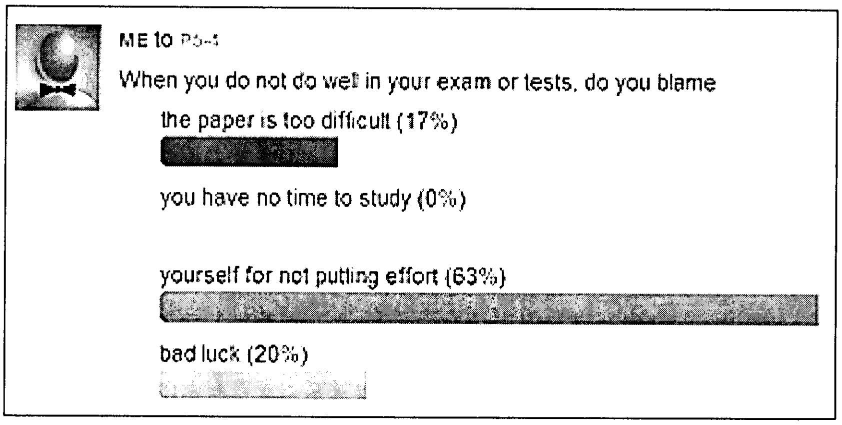
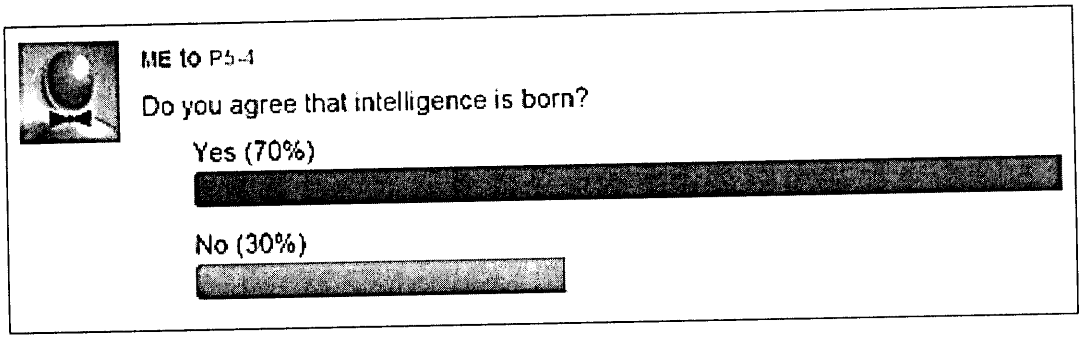


Figure 2. Students' perception on whether intelligence is a fixed entity.



The rationale for this pre-assessment on my students' self-belief was to give an indication as to whether my students believe in increasing their own intelligence. To prepare these students for transition from a mixed approach in teaching to an idea-centred teaching, the following were the lesson activities which took place prior to actual lesson proper. I discussed with the Form Teacher of the class the group seating arrangement of the students and laid down the rules for engagement: 1) Ready to Share, 2) Ready to Listen, 3) Ready to Improve and 4) Momentum for continuous improvement (S.L.I.M). These rules were important when ideas flew 'fast and furious' as the students interacted and engaged passionately with one another's ideas. The rules set the tone of the environment that allowed free expression of ideas and no one was to be left behind or ridiculed.

Students were introduced to the Wright Brothers' story (Jakab, 1990), via a video clip from YouTube which was customised, to gain an understanding of how ideas were generated and improved by collaborating with the knowledgeable others. They learnt that ideas could come from trying to achieve a goal, to solve real problems or simply to make a dream come true, like the Wright Brothers who held a dream that mankind would be able to soar like a bird one day. Students volunteered to share their dreams while others gave comments, suggestions, or feedback.

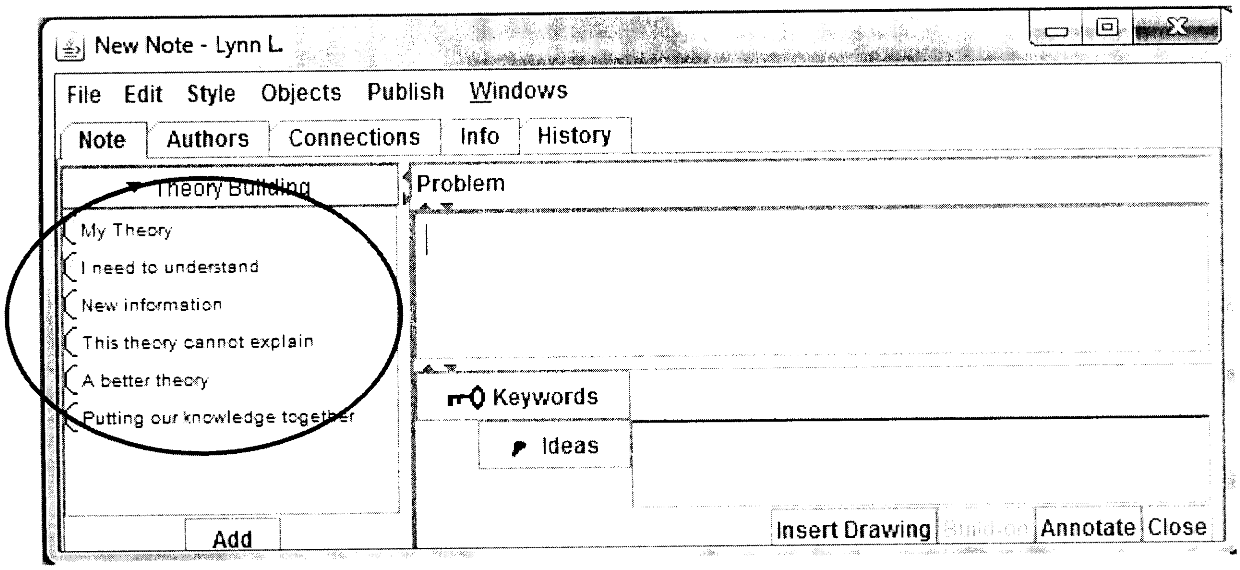
During a class discussion of the Wright Brothers' story, students highlighted the need to have ideas and that all ideas were improvable as long as the brothers worked collaboratively with the knowledgeable others who were at that time also working on a flying plane. They consulted scientists, worked and thought like scientists as they improved on their subsequent experiments to build a better flying plane. The conclusion drawn from the class discussions was that the Wright brothers and the people who helped them had a shared common goal, which was to build a flying plane that could fly a further distance and land safely.

Using the Wright Brothers' story, the principles of KB were introduced to the students. They learnt that everyone is capable of coming up with ideas (Diversity of Ideas) and initial ideas can be improved with the help from the more knowledgeable others (Improvable Ideas). By getting the students to imagine that an idea looked like a dot, the number of ideas produced by the class with each one contributing at least one idea (I drew several dots) and then everyone contributing at least one idea to a peer (I drew one dot to each existing dot with connecting line), the students saw the amazing proliferation of ideas! Instead of having only one idea to oneself, the students saw that in a matter of minutes, there were tens of ideas accessible to them! Using these two principles, I explicitly told the class; 1) No one person can learn more than the whole class put together, 2) Knowledge is accessible even without a teacher's presence and 3) You do not have to wait for knowledge to land on your lap, but instead, you can tap on the knowledge of others.

Lessons were designed based on the two principles of KB for 3 topics: 1) Human Body System, 2) Heart Organ and 3) Human Reproductive System. The first two topics were conducted in Term 1 and the last topic in Term 3 (Appendix 1), and the KF tool was used to capture students' ideas and their interaction patterns.

The students were encouraged to express their ideas and questions freely and I refrained from correcting their ideas or giving answers to their questions. They were told that they were to learn from one another and everyone was responsible to help one another to learn more about a topic. The first topic was the first lesson to immerse the students in a student-centred and an idea-centred learning environment. The students were new to KF and their ideas and questions were captured by a teacher assistant. For the next two topics, the students used the KF to post their ideas and questions (called 'notes' in KF terminology), read all the notes and were encouraged to build onto their classmates' notes using the scaffolds circled in Figure 3.

Figure 3. Knowledge Building scaffolds.



Method

(A) Enacting two principles of Knowledge Building

First KB principle – Diversity of ideas

(1) Generate

To immerse the students in the process of learning in an idea-centred classroom, I used a trigger to get students to think and respond. The triggers could be in the form of big ideas/questions, pictures or videos.

(2) Read / Respond

After the presentation of the trigger, students were invited to share one idea/question. These were captured and displayed for students to read. When a student posted his or her idea onto KF platform, a 'note' was created. This was a term used in KF language. Every student must read all the ideas/questions (notes in KF platform). Thereafter, students were invited to respond to their peers' ideas/questions. They were given the choice to choose any number of ideas/questions to respond. By responding to the notes, the students created 'build-on' notes, a term used in the KF language.

Second KB Principle – Improvable idea

(3) Research / Respond

Students were encouraged to conduct research using print and online resources to support their ideas with evidence/facts and find answers to the questions posed. Armed with more evidence-based information, they responded to their peers' ideas/questions. These responses were categorized as second cycle of ideas generation but with more 'meat' since these contained more scientific information than the original ideas.

(4) Improve ideas

Again, students must read all responses, not only to their original idea/question, but also including responses to others'. From here, they would have gained a lot more information and formed new ideas, better explanations, or rudimentary theories. On the other hand, they would generate more ideas/questions from their peers' responses. Thus, through this cyclical generating of and improving on ideas, learning took place and new knowledge created as well.

(B) Sample

Both experimental and control classes consisted of mixed-ability P5 students. Their P4 SA2 results ascertained that they were comparable in terms of their academic abilities. The experimental class was P5-4 while the control class was P5-5.

(C) Lesson Design

Throughout all the three terms of science lessons, KB pedagogy was applied. However, in Term 2, lessons were conducted without the use of KF. In Term 1, KB and KF were used for lessons on 'Human Body System' and 'Heart Organ'. In Term 2, only KB pedagogy was used and ideas were captured using graphic organisers instead of KF. Cooperative learning strategy was used to engage all students to contribute ideas within groups and sharing groups' ideas within class. After having heard from all the groups' ideas, students within groups improved on their original ideas with more information and explanation. In term 3, both KB and KF were used for lessons on 'Human Reproductive System' (Appendix 1).

(1) Immersion into KB culture of learning – Human Body System

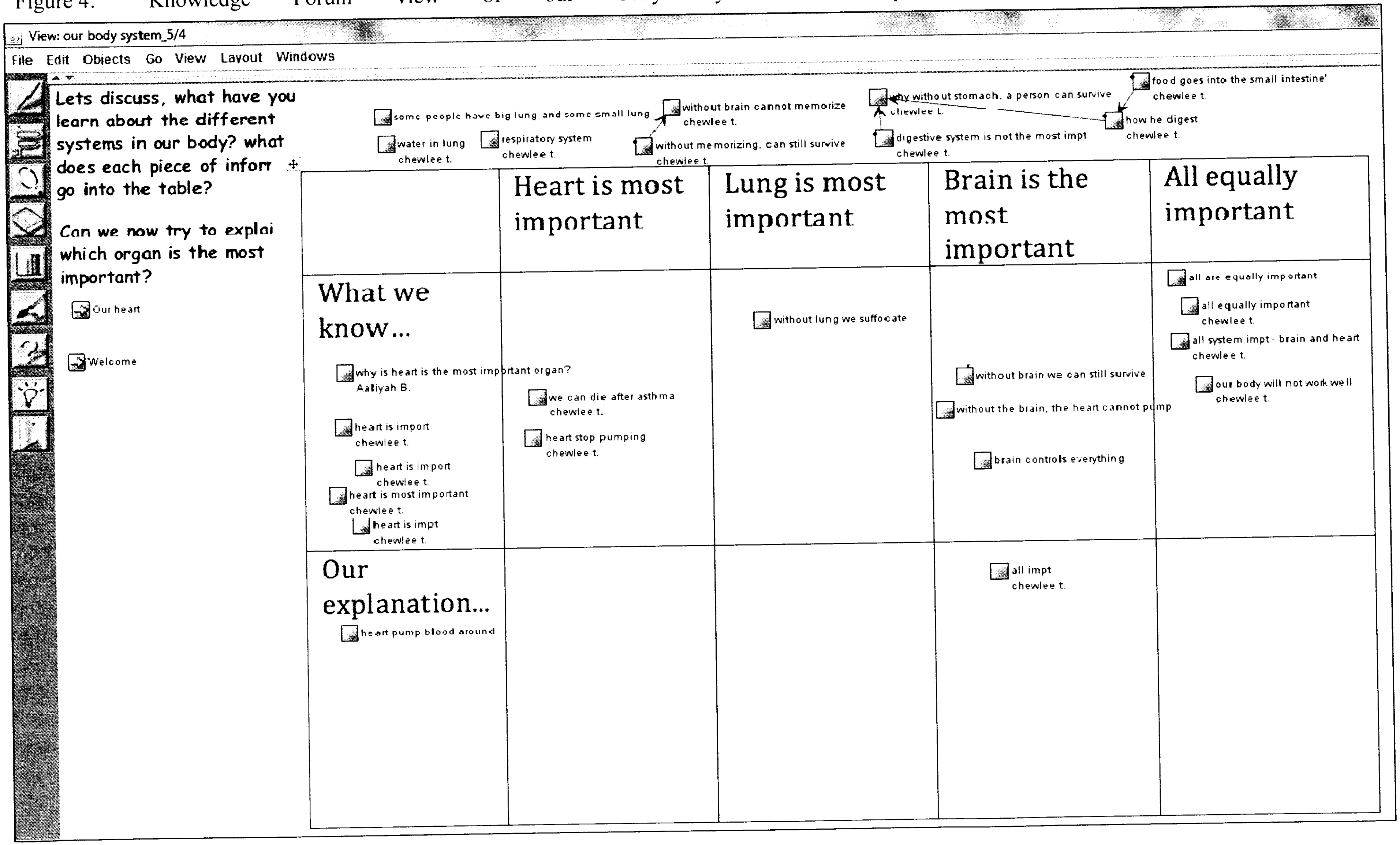
In order to immerse students into a KB culture, an introductory lesson was designed to expose students to the two principles of KB. A (trigger) question was posed: How do our body systems work together? Students were encouraged to come up to the front of the class and share one idea/question. These were captured using MS Word document and displayed on the screen for the entire class to read. Next, they were invited to respond to any of these ideas/questions. Since every student was expected to contribute at least one idea/question and that was their first KB lesson, I also accepted students who were not able to contribute any of their own, to just state whether they agreed or disagreed to these ideas/questions. I did not give any prompt nor provide any answers to these questions. This act was important to promote a sense of ownership of ideas; they produced the ideas/questions, the responsibility lay on them to find evidence or answers for themselves.

In another lesson, I posed a question: What would happen if we do not have a respiratory system? The objective was to move them towards talking about other organ systems that might lead them to talk about the heart. What followed was the most memorable and impactful flow of the lesson; one student exclaimed that the heart was the most important organ and other students started to state their own claim that their selected organ/system was the most important for human to survive. There were exchanges amongst the students, each arguing for his or her idea. They wanted to have their ideas heard and wanted an answer from me as to which organ was the most important.

The students were divided into different groups; each representing the organ/system that the students selected as the most important. Each group's representative was given one minute to share his/her group's ideas and to convince members from other groups to join them. Their ideas were expressed based on opinions and not facts, and there was very little scientific information to support their views. It was a good opportunity to teach them the difference between the two; opinions are just ideas without basis and tend towards biasness whereas facts are established truths, tested and supported by evidence. The students were encouraged to read print and online resources to search for facts to support their claims.

In the next lesson, the students were brought to the computer laboratory and their ideas were captured using KF platform (Figure 4) by a teacher assistant. With KF, students were able to see their ideas grouped according to the organ that they deemed most important for survival. This visual enabled the students to see the number of votes cast for each organ. This was the first time the students were exposed to the KF platform. In this lesson, there was deliberate intention to move students from written ideas on paper to writing ideas onto an online platform.

Figure 4. Knowledge Forum view of our body system as captured by the teacher assistant.



(2) Using KF platform – 'Heart Organ' view

For this lesson, the students were brought to the computer laboratory and they were shown two silent videos featuring; a 3-D animation of a human heart beating while rotating in 360° turn and another showed a running man with a graph display of his heartbeat at different speeds of running. The videos served as triggers for students to generate ideas about the heart.

The 'Heart Organ' view was created for this lesson to capture students' ideas (Figure 5). A view was a term used in the KF terminology which contained students' ideas. They were given time to type out their ideas onto KF platform. For each idea that the students created in KF, a note was created. A note in KF represented one idea. An unread note was blue in colour while a read note was red in colour. When all had contributed their notes, they were given time to read everyone's notes. Next, they were taught how to create build-on notes. The students were instructed to reply to their peers' notes and they were given the choice of whose notes they would respond to. Each response created by the students on their peers' notes was termed as a 'build-on' note. A build-on note had an arrow pointing towards the original note that was built-on to (Figure 6a). In Figure 6b, the contents of linked build-on notes were shown. The students were reminded to provide facts when responding to their peers' notes.

A few notes were selected and opened as examples of good notes which should contain an appropriate title, use of scaffolds and appropriate content of the note. A couple of notes were opened to demonstrate a non-useful note with contents containing "OK", "Thank you" and "Now I know." The students were told that the purpose of KF as an online platform for collaboration was to post useful notes and questions to propel the learning community towards knowledge improvement. It was not to be used like other social media tool such as Facebook or Twitter.

The last part of the lesson ended with students reading build-on notes and were told to research for more information to either understand or validate the build-on notes or to be ready to provide useful information to their peers in the next lesson. Through this cluster of notes, students learnt that their ideas could be challenged or supported by their peers or could help others to generate more ideas/questions for further inquiry. Further investigation into new lines of inquiries was important to help students deepen their knowledge in the areas of their interests.

Figure 5. A view of 'Our Heart' in Knowledge Forum.

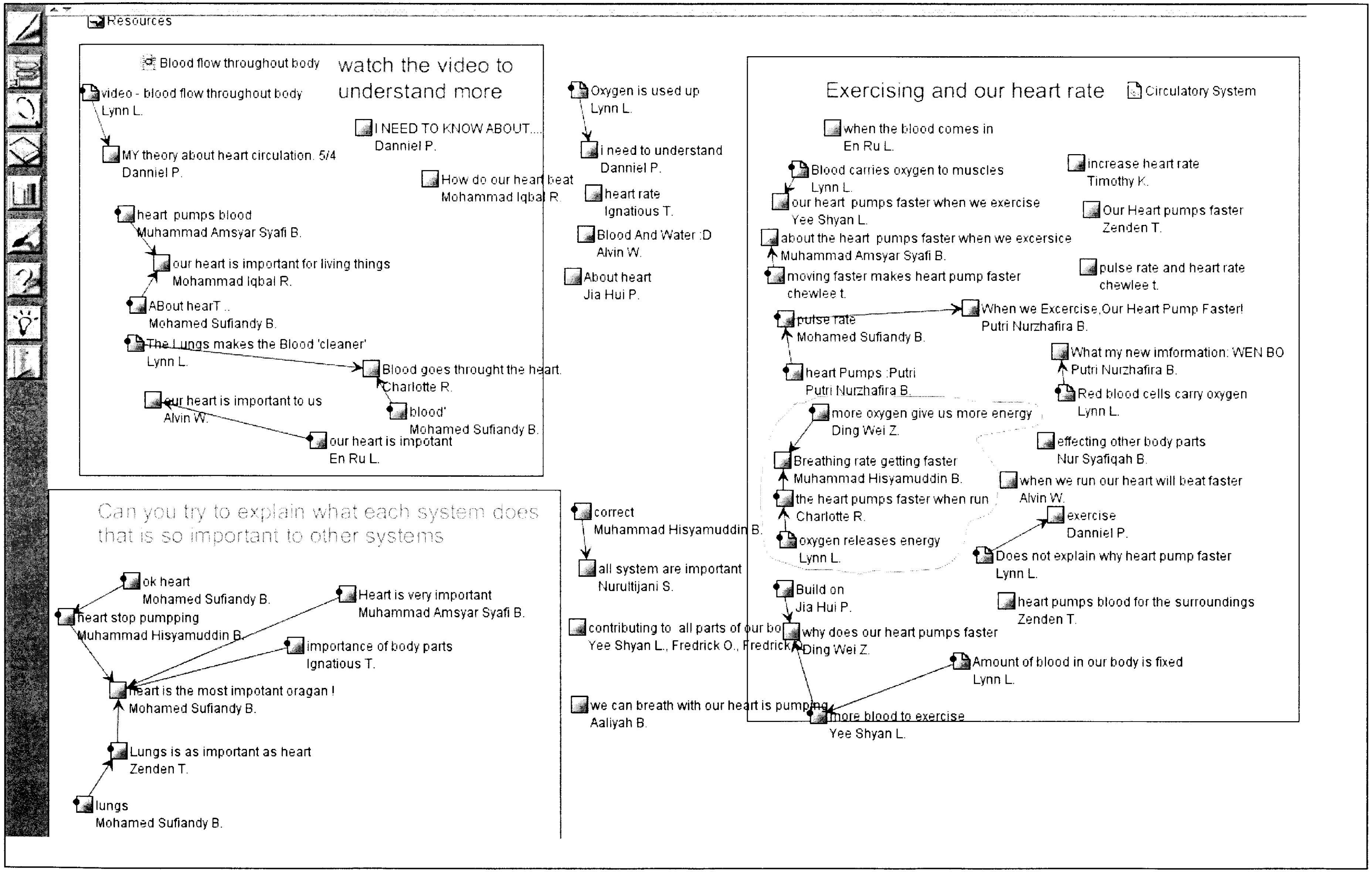


Figure 6a. An example of build-on notes.

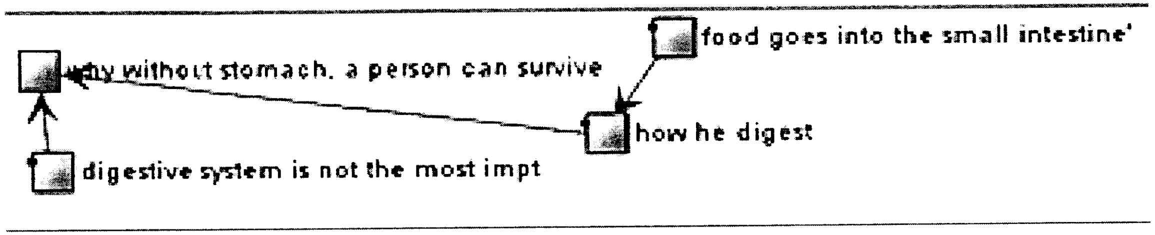
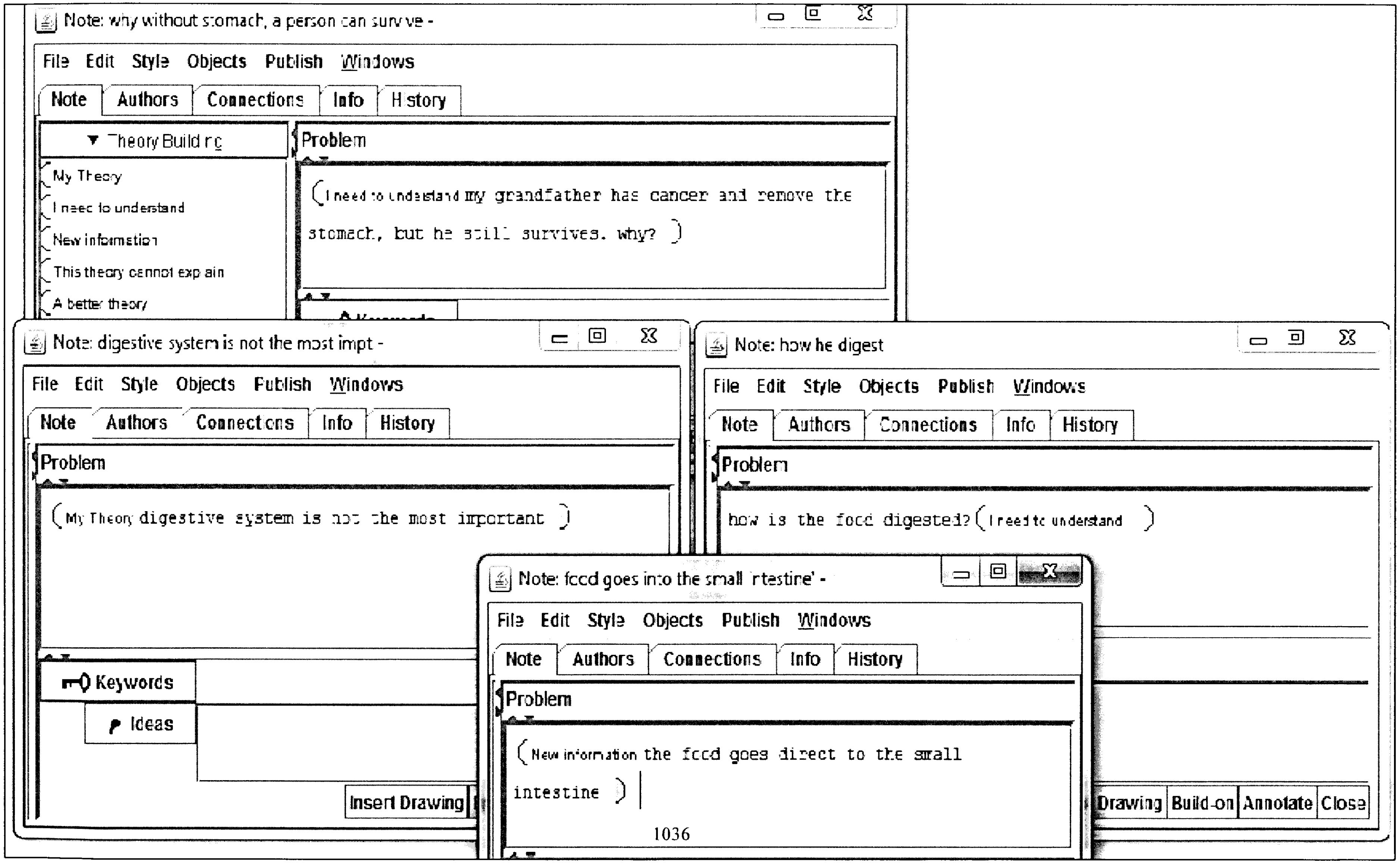


Figure 6b. Contents of build-on notes from figure 6a.



(3) Using KF platform – 'Human Reproductive System' view

Two short animation clips were shown to the students in two separate lessons. The animation clip was used in the introductory lesson for the human reproductive system. It showed an egg released from an ovary and followed by several sperms swimming towards it. The animation clip ended with only one sperm entering the egg, both nuclei were fused, and then the fertilised egg divided into many cells (Figure 7a). Many ideas/questions were generated by the students and were captured onto the whiteboard. Students volunteered to answer some of the questions and finally, those correct answers were consolidated. Those unanswered questions were kept for the next lesson.

A second animation clip was shown (Figure 7b). An egg was released by an ovary in a female reproductive system, moved along the fallopian tube and fused with a sperm. The next segment showed the fertilised egg travelling towards the womb. Students generated questions which were also captured on the whiteboard. Cooperative learning strategy was used and students worked in groups to find answers. Group representatives shared their answers to the questions raised. Through facilitation, students arrived at some answers to these questions while generating even more ideas and questions. Within this lesson, students learnt from their peers about the terminologies for the organs, the fertilisation process and arrived at some understanding on the one-egg-one sperm scenario. In fact, a few of the unanswered questions from the first lessons were answered in this lesson. In the third lesson, students posted their ideas/questions onto KF (Figure 8).

Figure 7a. Screen shot of the animation clip showing the fertilisation of an egg by a sperm.

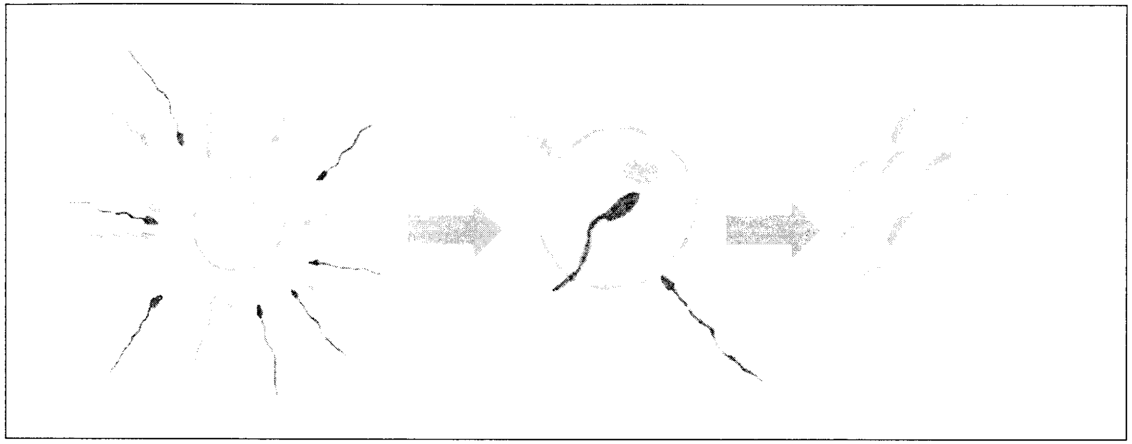


Figure 7b. Screen shot of the animation clip showing the fertilisation of an egg by a sperm in a female reproductive system.

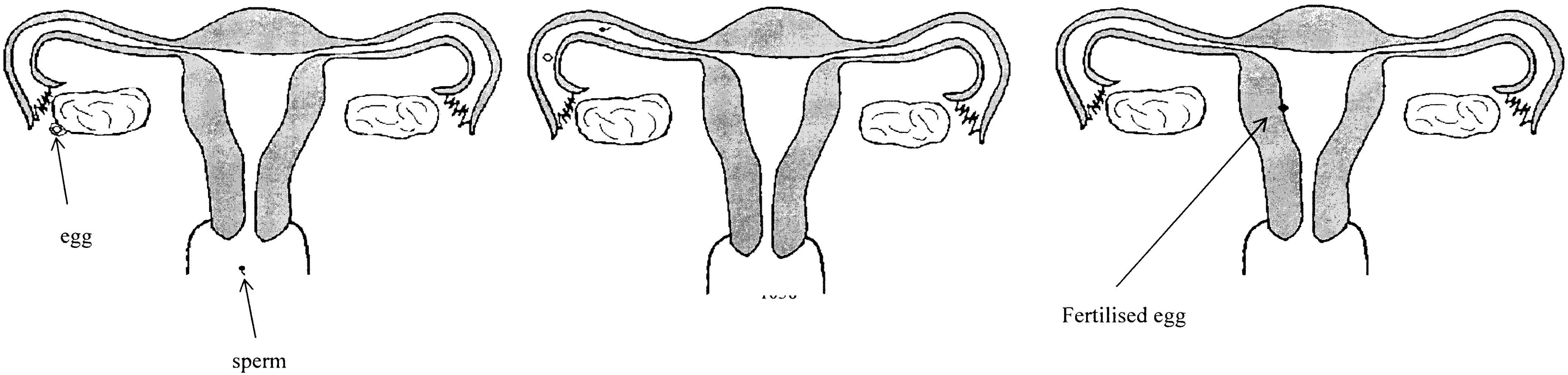
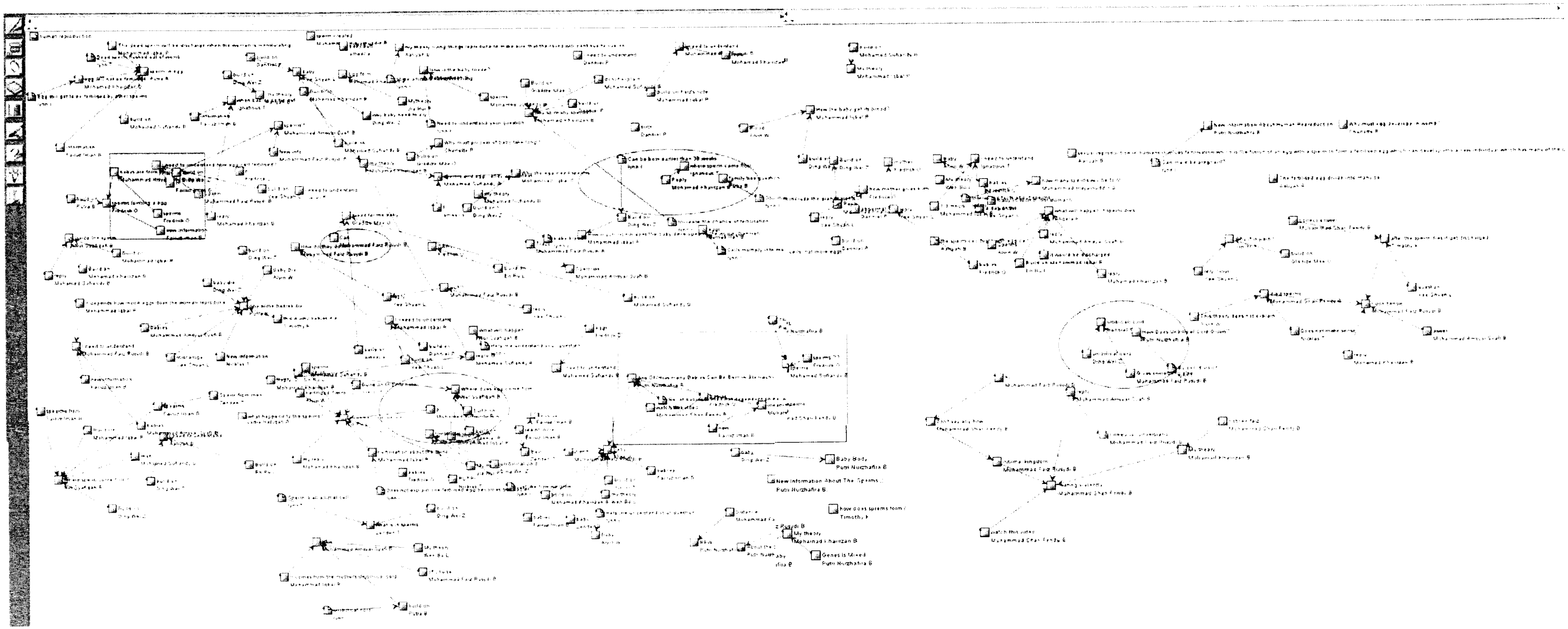


Figure 8. A view of 'Human Reproductive System' in Knowledge Forum.

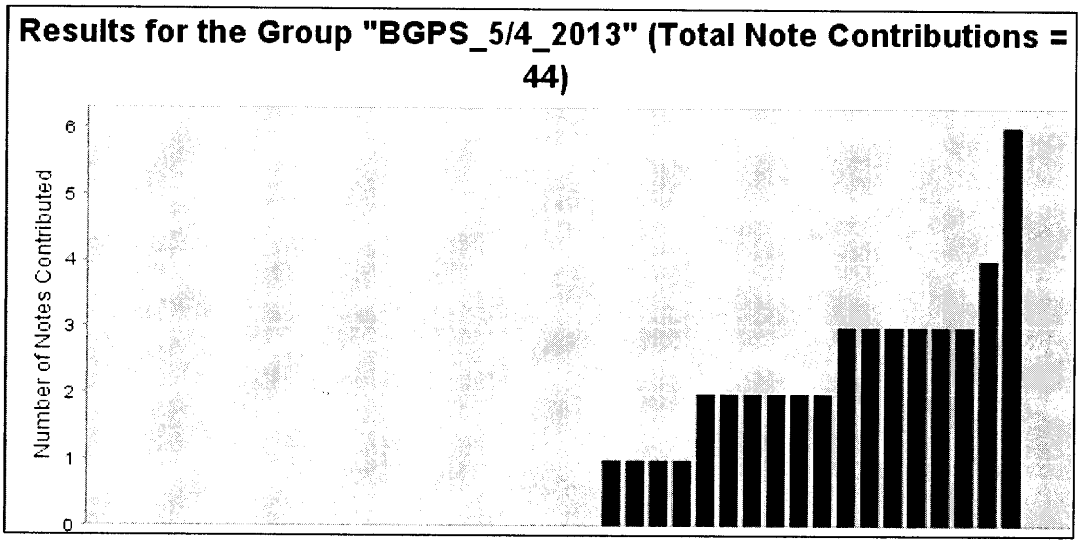


(D) Collection of data

Students' ideas/questions were captured in the views created for the specific lessons on KF platform (Figure 5 and Figure 8).

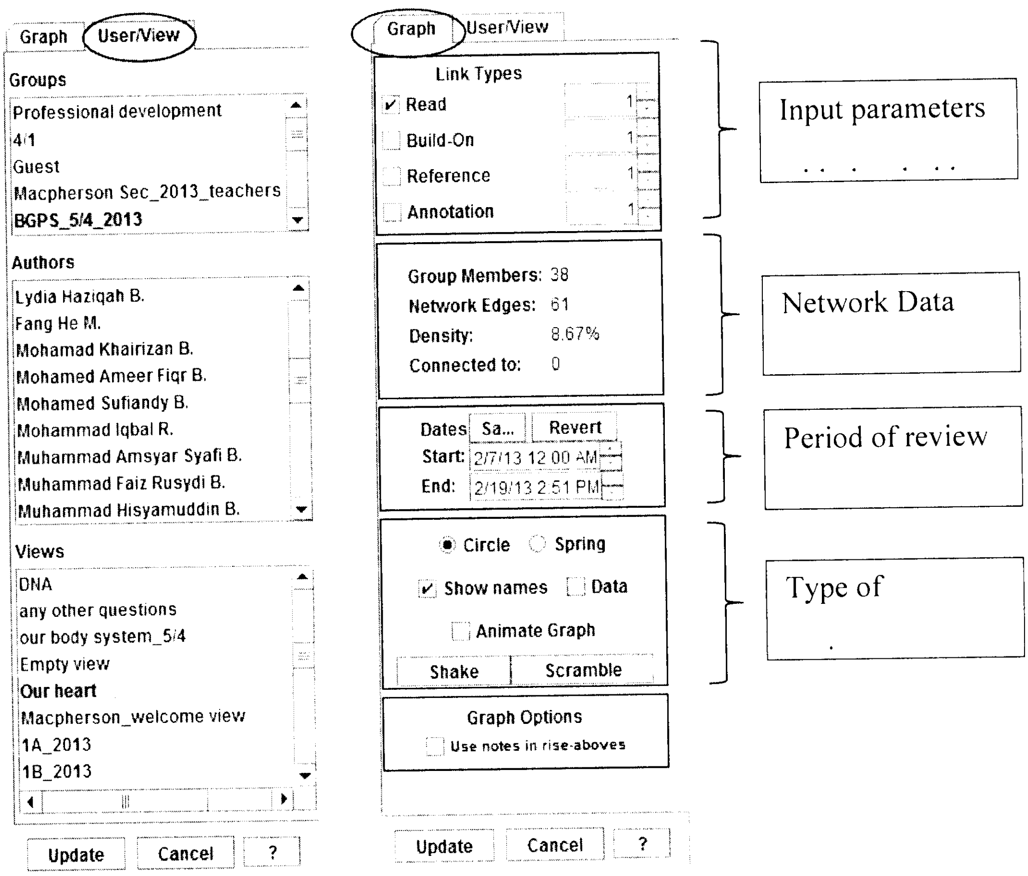
There were four assessment tools in KF and two were used in this study: 'Contribution' and 'Social Network'. The 'Contribution' tool displayed the number of notes contributed by each student as shown in Figure 9, in the 'Heart Organ' view.

Figure 9. Student contribution notes displayed by the 'Contribution' tool in Knowledge Forum.



The 'Social Network' tool was used to analyse the patterns of communication among students. It gave useful information about how individuals were progressing with respect to self-directed learning and collaborative learning skills. This kind of analysis took two forms; (a) a picture or map called a sociogram that showed who had communicated with whom; and (b) a set of mathematical measures (explained below) that gave further information. Lining the top of the sociogram are five tabs: 'Graph', 'User/View', 'Graph', 'Data' and 'Help'. For the purpose of this study, the first two tabs were used. The 'User/View' allowed display of sociogram based on the 'Human Reproductive System' view (Figure 10). The sociogram displayed the data in accordance to the 'Link Types' selected.

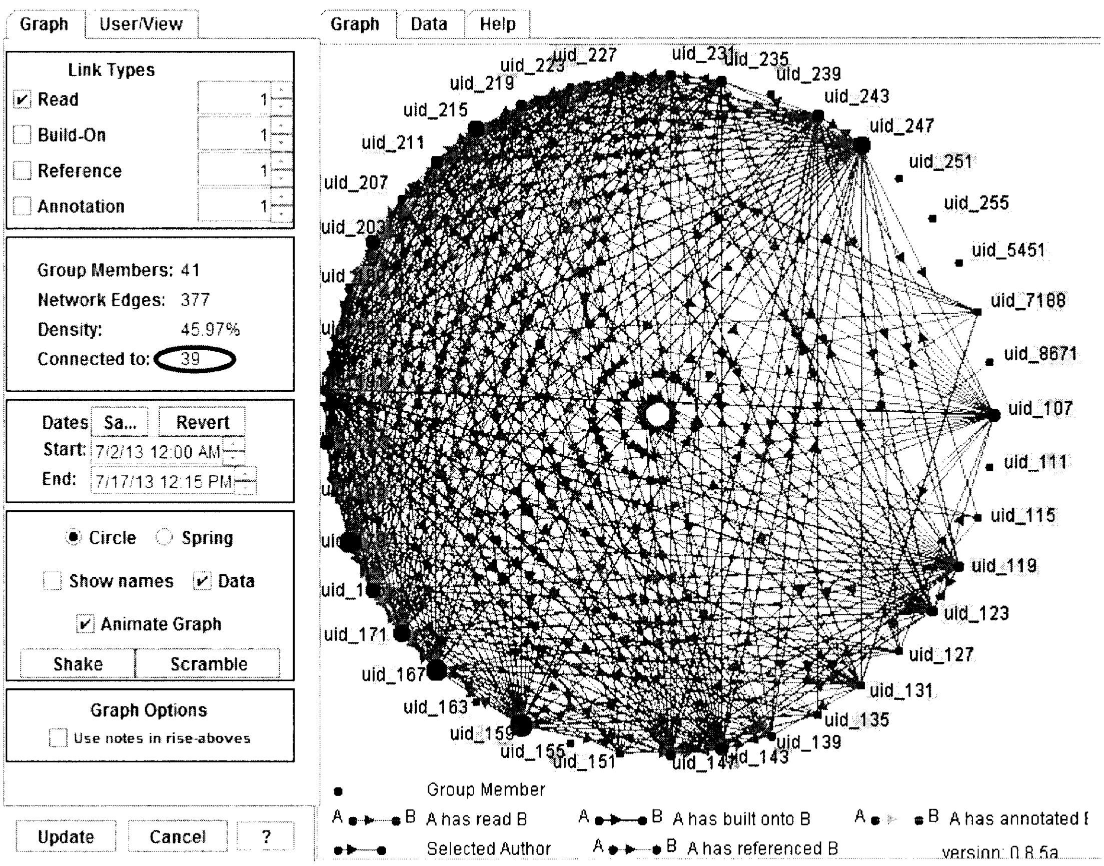
Figure 10. Display of 'User/View' and 'Graph' tabs in Knowledge Forum.



On its right, the field box allowed input of threshold. The tool allowed the teacher to see only communications at or above a certain threshold. Setting it to '1'displayed reading patterns of students who read at least one note in the selected view. The 'Build-On' option displayed the communication pattern of students responding to others' notes. The selection on 'Show names' allowed the identification of students while the option 'Data' replaced the names with codes.

Figure 11 showed the sociogram with the five tabs and threshold options. The 'Network Edges' (connecting lines) showed the number of student's communication with his/her peers. If person A builds-on person B's notes, then an arrow would point from A to B (A → B). Arrowheads pointing both ways showed reciprocal communication between two students. Network 'Density' displayed the actual number of communication links out of the total possible communication events. With reference to Figure 11, an almost perfect sphere with dense links indicated a well-connected class. The 'Connected to' showed the number of connections an individual had made with his/her peers.

Figure 11. A sociogram in knowledge forum.



(E) Students' academic performance

Students' academic results were collected for Continual Assessment in Term 1 (CA1), Semestral Assessment in Term 2 (SA1) and Continual Assessment in Term 3 (CA2) for two classes; experimental class, P5-4 and control class P5-5. The standard mean deviation (SMD) was calculated using the formula given below.

$$\text{SMD} = \left[\frac{\text{Mean (Experimental)} - \text{Mean (Control)}}{\text{Standard deviation (Control)}}\right]$$

Cohen's (1992) criteria were used to interpret the SMD values. Table 1 shows how SMD values could be related to the extent of effect of the treatment (KB pedagogy) administered to the experimental group. A SMD value of greater than 0.25 was considered educationally meaningful (Slavin, 1990).

Table 1. Interpretation of the Standard Mean Deviation (SMD) values

SMD value	**Extent of effect**
1.00 and greater	Very large effect
0.80 to 0.99	Large effect
0.50 to 0.79	Medium effect
0.20 to 0.49	Small effect
0.00 to 0.19	Negligible effect

Results and Discussion

(1) Data analysed using the assessment tools present in KF

The results are summarised in Table 2 and shown in Figures 12–14. The results showed that the number of notes contributed by students increased from 44 for 'Our Heart' to 216 for 'Human Reproductive System' (Figures 12a and 12b).

Table 2. Summary of findings from the 'Contribution' & 'Social Network' assessment tools

Views	**No. of notes**	**'Read' Network Density**	**'Build-on' Network Density**
Our Heart (Term 1)	44	8.53%	1.99%
Human Reproductive System (Term 3)	216	45.97%	12.07%

Figure 12a. Contribution graph on 'Our Heart' view (Total contribution = 44)

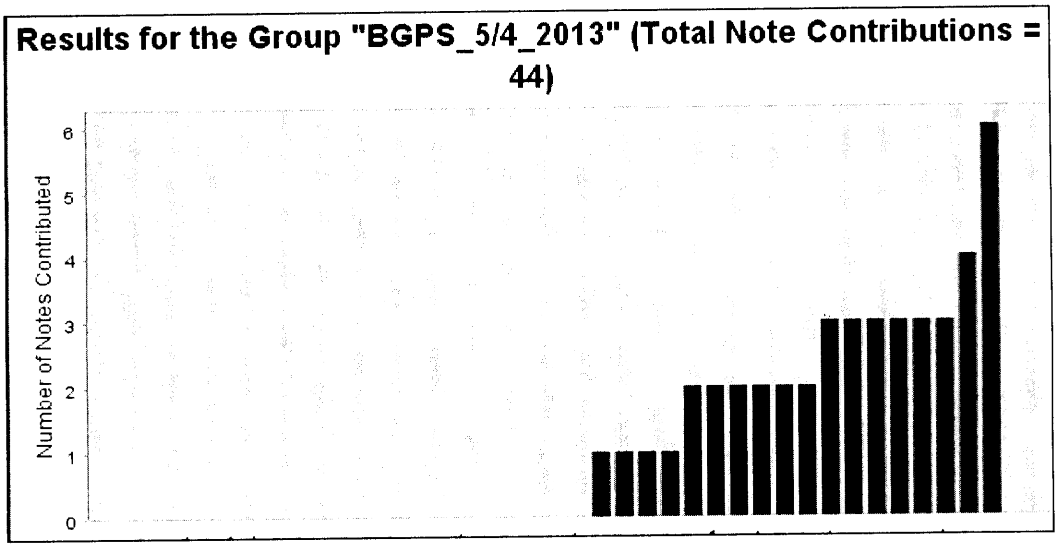
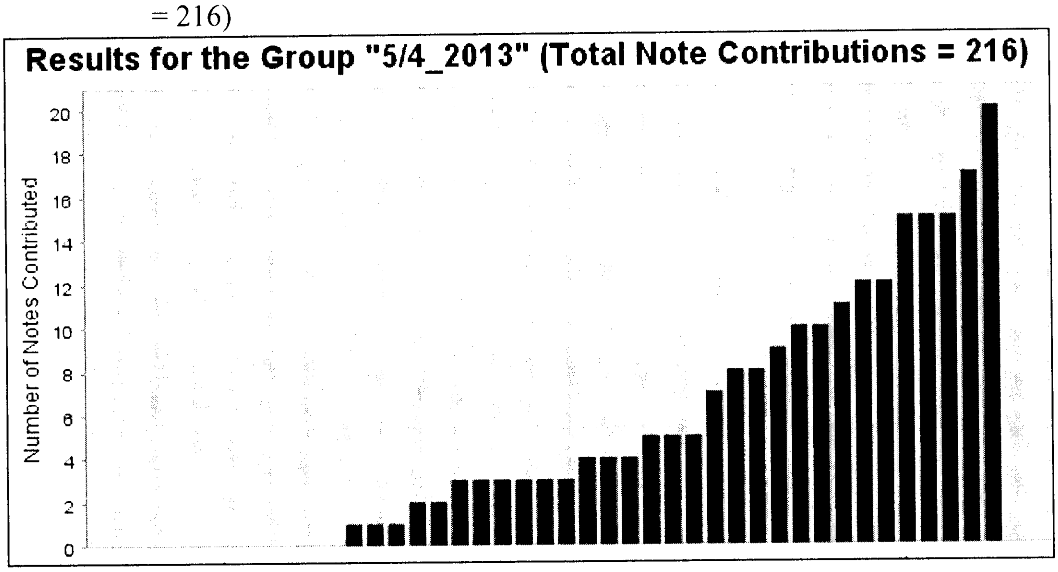


Figure 12b. Contribution graph on 'Human Reproductive System' view (Total contribution = 216)



The network density for the 'Read' option increased from 8.53% for 'Our Heart' to 45.97% for 'Human Reproductive System' (Figures 13a & 13b). Similarly, the network density for the 'Build-On' option increased from 1.99% for 'Our Heart' to 12.07% for 'Human Reproductive System' (Figures 14a & 14b). Both increases indicated that students exhibited increased self-directed learning as well as being collaborative in working with each other's ideas.

Figure 13a. Social Network analysis - 'Read' in 'Our Heart' view (Term 1).

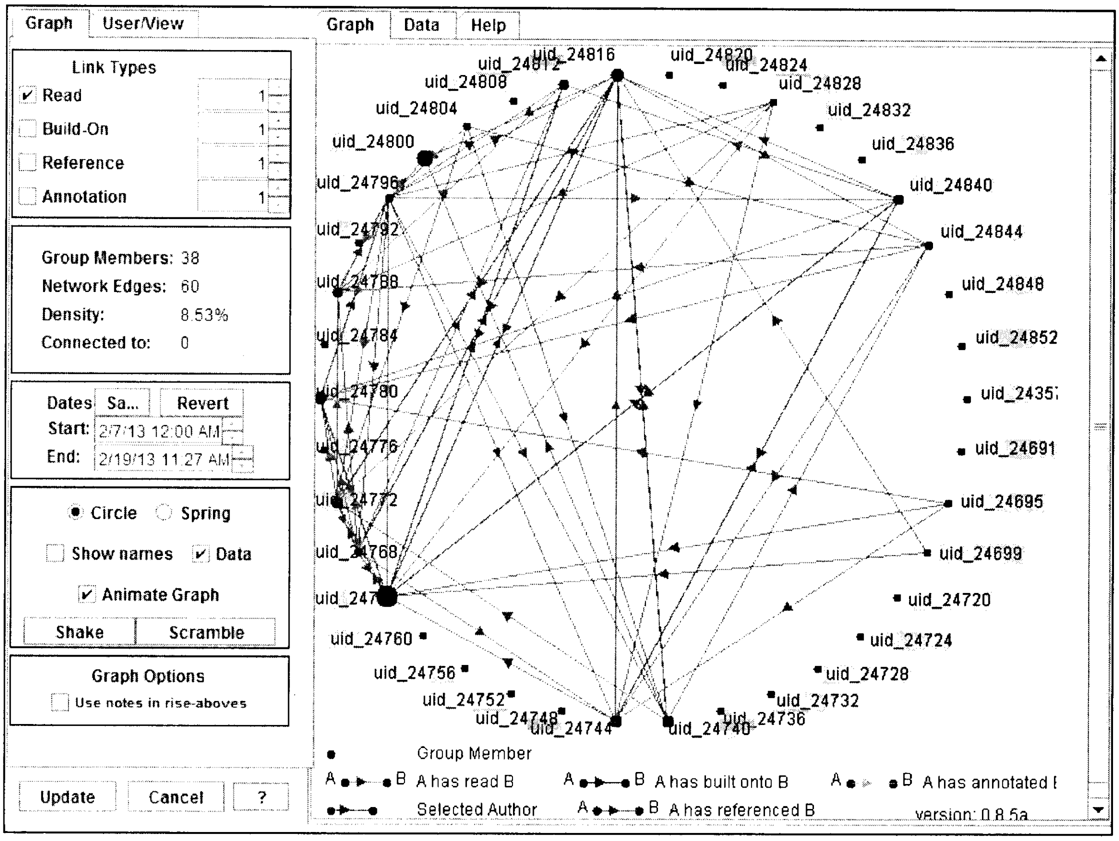
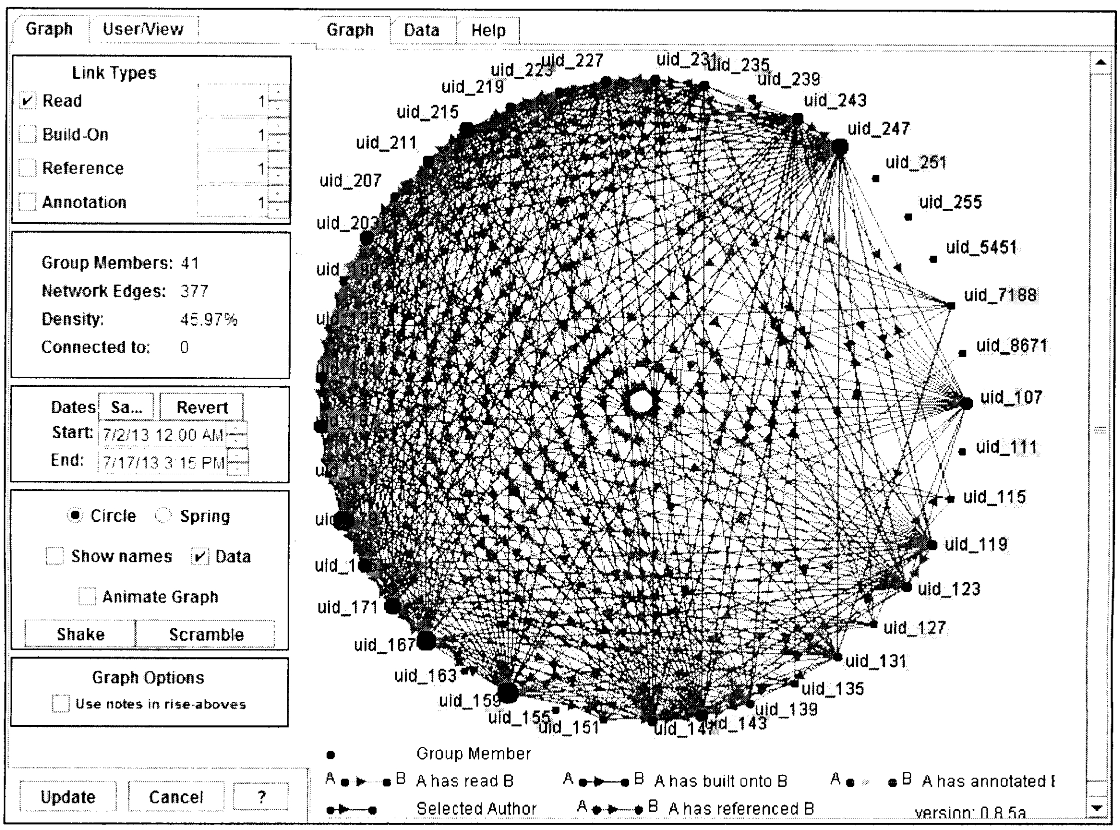


Figure 13b. Social Network analysis - 'Read' in 'Human Reproductive System' view



(Term3).

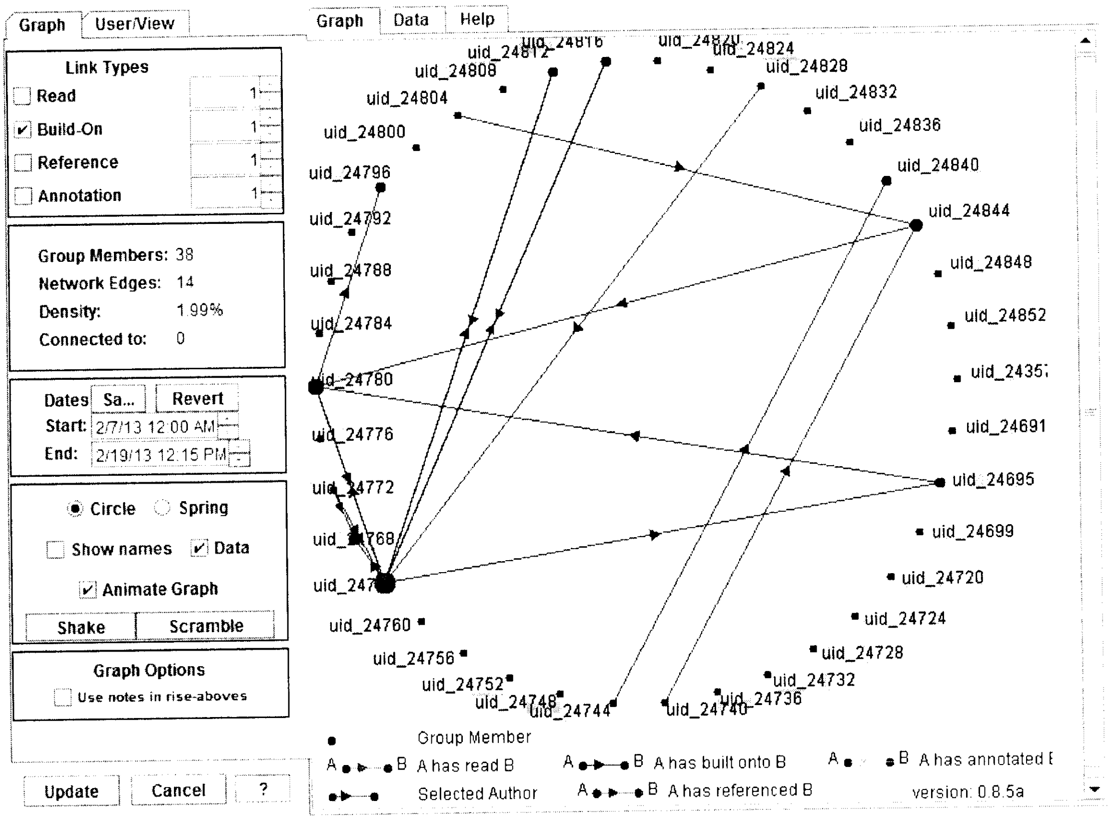
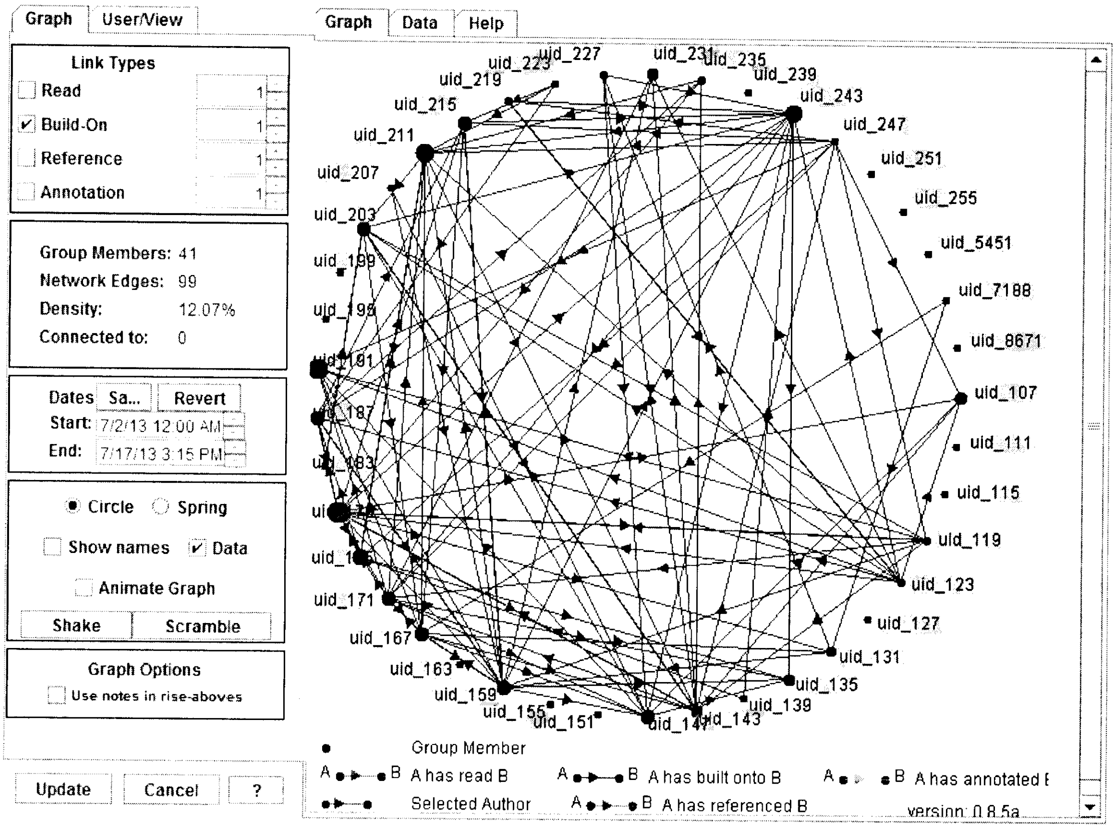


Figure 14a. Social Network analysis - 'Build-on' in 'Our Heart' view (Term 1).

Figure 14b. Social Network analysis - 'Read' in 'Human Reproductive System' view

(Term3).



Graph
User/View
Link Types
Read
Build-On
Reference
Annotation
Group Members: 41
Network Edges: 99
Density: 12.07%
Connected to: 0
Dates
Sa...
Revert
Start:
End:
Circle
Spring
Show names
Data
Animate Graph
Shake
Scramble
Graph Options
Use notes in rise-aboves
Update
Cancel
?
Graph
Data
Help
uid_219
uid_215
uid_211
uid_207
uid_243
uid_247
uid_251
uid_255
uid_5451
uid_7188
uid_8671
uid_107
uid_111
uid_115
uid_119
uid_123
uid_127
uid_131
uid_135
uid_139
uid_171
uid_167
uid_163
uid_159
Group Member
A has read B
A has built onto B
Selected Author
A has referenced B

(2a) Excerpts from students' build-on notes in 'Our Heart' view

Students worked on each other's ideas and attempted to resolve their query on which organ was most important for survival. Below were excerpts of the notes taken from the KF.

S1: *All our system work together to (help) us move and survive. My theory is the heart is the most important because heart pumps blood to all our parts of body to make them work.*

S2: *It is important because without the heart, the blood will stop pumping and we will not be breathing.*

S2 supported S1 with more information about the heart being most important as it helped in the 'breathing' process. S3 built-on to S1 with new information.

S3: *New information: all our body parts are important because if one of the systems is not working, our body won't work well.*

S4 built-on to S1with new information connecting the lungs for the breathing function which the heart depended on to function well.

S4: *If we don't have lungs the heart will fail too*

In the above set of notes, students were not able to demonstrate a sequential flow of events on how the heart would be affected when the lungs failed. Another cluster of notes showed students were interested in the relationship between exercise and rate of heartbeat.

S1: *why does our breathing rate will be faster after we exercise?*

S2 and S3 drew upon their prior knowledge on 'Respiration' to build on S1's note.

S2: *It is because when we exercise the heart pumps faster to give us more air.*

S3: *We need more oxygen to release more energy*

This set of notes showed that students (S2 & S3) were able to link the important function of the lungs in relation to the heart function during exercise.

(2b) Excerpts from students' build-on notes in 'Human Reproductive System' view

S1: *what will happen if the sperm dies in the womb?*

It was interesting to note that the following build-on notes to S1's notes denoted a certain process or sequence of events.

S2: *Then the egg will not be fertilised*

S3: *It would be discharged when the woman is having menstruation.*

S4: *Then it will not form any baby.*

Similarly, another cluster of notes on sperms showed a logical sequence of events.

S1: *what if the sperm that's inside the egg died half way inside?*

S2: *Then the egg will not be fertilised.*

S3: *The egg will still get to be fertilised by other sperms; there are so many of them swimming to the egg.*

S3 brought forth new information into the cluster of notes.

Comparing the notes from 'Our Heart' and 'Human Reproductive System' showed that students were improving on the way information was shared. In the latter topic, the notes showed a distinctly logical flow of information.

(3) Students' academic performance for CA1, SA1 and CA2.

Table 3 shows the academic performance of the experimental and control classes over Terms 1 to 3. The experimental class P5-4 scored a mean of 43.36 (with SD of 9.84) while the control class P5-5 scored a mean of 42.31 (with SD of 12.25) for CA1. There was a mean difference of 1.05 in favour of P5-4. The corresponding SMD value was 0.09, which was considered to be of negligible effect based on Cohen's criterion.

For SA1, the experimental class performed better than the control class and the mean difference was 5.26 (Table 3). The corresponding SMD value was 0.45, which was considered to be of small effect (Cohen, 1992). For CA2, the experimental class scored better than the control class again. The mean difference was 8.03 and the corresponding SMD value was 0.55 (Table 3). This showed that the KB pedagogy had a medium effect on the experimental group.

Table 4 summarises the SMD values for the assessments over Terms 1 to 3. The SMD values increased from 0.09 for CA1 in Term 1, to 0.45 for SA1 in Term 2, and to 0.55 for CA2 in Term 3. It appeared strange that intervention prior to CA1 (in Term 1) did not produce any pronounced effect on this assessment. A plausible reason could be that the experimental students were learning to adapt and cope with a different style of learning in Term 1 and thus the effects of KB were not obvious. The SMD values of SA1 and CA2 were greater than 0.25; this implied that the KB pedagogy administered to the experimental class was educationally impactful (Slavin, 1990).

One limitation of this study was the lack of a pre-test and a post-test. A pre-test should be administered to both experimental and control classes to ascertain that they were indeed comparable in terms of academic abilities. A post-test containing the same items as the pre-test should be administered after the intervention in order to ascertain the effects of the KB pedagogy on students' learning. Both pre-test and post-test were not administered in this exploratory study due to time constraint and the lack of support from the school management to provide an allied educator to assist in relieving administrative matters.

Table 3. Comparison of academic performance between experimental and control classes from CA1 to SA1 to CA2.

Test	**2013 Science CA1 Term 1**		**2013 Science SA1 Term 2**		**2013 Science CA2 Term 3**	
Class	P5-4*	P5-5	P5-4*	P5-5	P5-4*	P5-5
Sample size	33	29	33	29	33	29
Mean score	43.36	42.31	56.50	51.24	52.35	44.32
Standard deviation	9.84	12.25	9.67	11.77	13.04	14.49
Mean (Experimental) – Mean (Control)	1.05		5.26		8.03	
Standard mean deviation	0.09		0.45		0.55	

*Experimental class

Table 4. Comparison of SMD values across three assessments.

Indicators	**CA1 (Term 1)**	**SA1 (Term 2)**	**CA2 (Term 3)**
Standard mean deviation	0.09	0.45	0.55
Extent of effect	Negligible effect	Small effect	Medium effect

Implications

(1) Future study

The study showed favourable outcomes in using KB as pedagogy to teach Science. KB practices support the constructivist view that knowledge must be actively constructed by learners and is assimilated best in a social setting. Moreover, KB is a principle-based practice (Scardamalia, 2006) which situates students in a natural context for SDL and CoL to take place. With KF, students can write their ideas in private, be given time to think about them and then post them onto the platform. Every KB student owns her/his idea by signing into the platform and since everybody has to own her/his ideas, it becomes a norm to take responsibility to improve the ideas further.

Although there was a positive impact on my students' learning, it was not for certain that KB pedagogy was the sole reason for the difference. The reason being that the study was conducted over three terms as compared to other studies which were conducted over a few years. It might be too early to tell whether KB pedagogy was definitive in bringing about increased SDL and CoL skills and resulted in improved performance in assessments. The only conclusive finding was that it did not cause a negative impact on students' performance.

Future studies should be conducted to generate more data to triangulate results. Examples include the following; pre- and post-surveys on students' perception of self, motivation, how they learn, interviews on their understanding of nature of science. Possible research questions to consider are as follows:

How do the teachers' understanding of CoL and SDL shift as they engage in knowledge building technology?

(a) Does a teacher's classroom practices promote students' motivation?

(b) Does the motivation lead to students' increase in self-directed and collaborative learning?

How does students' understanding of the nature of science improve when adopting knowledge building technology? How does this improved understanding of the nature of science improve their SDL and CoL?

(2) Teacher's reflection

The effects of KB with use of KF were not immediate. It took me a term of practice before I was comfortable using it. In Term 1, I was constantly worried about not being able to complete the syllabus because a great deal of time was taken up by posting, reading and responding to notes and getting students to adhere to rules of engagement required a lot of classroom management. For my lesson preparation, it was time-consuming to read all notes, categorise them and align them to the curriculum. Yet, I had to be mindful about completing all pen-paper assessments and assignments which would be checked by the management.

Psychologically, I had to perpetually brace myself whenever a test or an assessment was around the corner, fearing a negative performance by my students which would lend guilt for 'using' them for experimentation. Prior to embracing KB pedagogy, I often wondered if my students could possibly learn from each other without me providing answers and explaining an answer repeatedly. I feared not being able to complete the syllabus; I feared my students would not be well prepared for their examinations; I feared the price that my students and I had to pay for throwing away long-held proven practices and embarking onto something new. In addition, I needed understanding and support from my management while my students and I embarked on an odyssey to a frontier that very few had explored in the Singapore context.

Zhang, Hong, Scardamalia, Teo, & Morley (2011) reported several important aspects in which leadership support is needed in sustaining KB pedagogy. It is a very new pedagogy in the Singapore context and only a few schools are attempting it. My school leaders were not aware of its existence prior to my study and were not fully convinced, despite my attempt to describe KB pedagogy and inform them of the positive impact of KB on students' learning. Although school leaders supported my initiative to try out KB pedagogy and demonstrated their trust in my capabilities, they did not participate in any of my weekly professional learning and sharing to understand the advancement and the challenges that I had faced and my need for resource support.

I had to grapple with learning how to incorporate KB into my teaching, juggling with teaching and marking load on top of teaching a graduating class while at the same time, fulfilling my duties as the School Coordinating Mentor for practicum trainees and as an Instructional Mentor for two other beginning teachers. In CA1 performance, when my students did not meet the academic targets, my school leaders were very worried. I had to persist and due to the commitment to the Edulab project, my KB work continued. However, when the SA1 and CA2 results showed great improvement, my school leaders were more supportive and recognised my work by providing me the opportunity to share with the E2 Cluster school leaders including the cluster's superintendent.

I believe more research is needed on my KB practices. Only through research, would more teachers be convinced to take up KB as the default teaching pedagogy for Science in my school.

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Appendix 1

Science Scheme of Work 2013

Term	Wk	Theme	Chapter	Topic	use of KB	Use of KF
1	1	Systems	Ch 1 – Systems in Living Things	(A) Air, breathing and the respiratory system		
	2			(B) The human circulatory system	✓	✓
				(C) Different systems working together		
	3			(D) Transport system in flowering plants		
	4		Ch 2 – Cells	(A) Cells – the building blocks of life		
	5			(B) Plant and animal cells		
	6		Ch 3 – Electrical System	(A) Sources of electricity (B) Electric circuits (C) Circuit diagrams	✓	
	7					
	8		Process Skills/Revision			
	9		CA 1			
	10		Item Analysis/Extension			
2	1			(D) The effects of the components on an electric current	✓	
	2			(E) Electrical conductors and insulators		
	3			(F) Safe use of electricity (G) Energy conservation		
	4	Cycles	Ch 1 - Water	(A) The three states of water	✓	
	5					
	6			(B) The water cycle		
	7			(C) Why is water important to living things? (D) Taking care of our water resources		
	8		SA 1			
	9		Item Analysis/Extension			
	10		Ch 2 - Reproduction in Plants	(A) Reproduction		
3	1			(B) Reproduction from spores		
	2			(C) Sexual reproduction in flowering plants		
	3					
	4					
	5		Ch 3 – Sexual Reproduction in Humans	(A) Sexual reproduction in humans (B) From parents to offspring		✓
	6	Energy	Ch 1- Energy and Photosynthesis	(A) Energy and the need for it	✓	
	7			(B) Photosynthesis		
	8		CA 2			
	9		Item Analysis/Extension			
	10			(B) Photosynthesis		