Title	Integrating technology in classroom: A study of a teacher's goals, knowledge and beliefs
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Source	Asia-Pacific Education Research Association Conference 2008, Singapore, 26-28 November 2008

Integrating technology in classroom: A study of a teacher's goals, knowledge and beliefs

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Abstract: This study probes into the goals, knowledge and beliefs of a teacher who has had decades of teaching experience as she starts to adopt technology in her classroom teaching. The technology is Group Scribbles (GS) which supports rapid collaborative knowledge building (RCKB). Over a period of one year, we worked closely with the teacher together with another teacher to co-design the lessons enabled by GS for elementary grade 4 and 5 classes. An integrated framework based on RCKB and the Teacher Model Group (TMG) model is used to present out findings. We discuss the inter-play between the teacher's knowledge, beliefs, goals as well as the classroom culture, and how that shapes her enacted practices in leveraging GS technology effectively for her class lessons. These traits and their interactions seem pivotal in overcoming obstacles in integrating GS technology in teaching.

Keywords: Teacher change, technology integration, technology in the classroom

1. INTRODUCTION

There is much consensus that technology is now an inevitable and integral part of our everyday life, work and home experiences. Concomitantly, the call for schools to move to a more technologically integrated approach to teaching and learning has been resonating among ministries or departments of education in various countries. In Singapore, this is evidenced in the IT Masterplan Two (mp2) (Ministry of Education, 2004). The key focus of mp2 is the deployment of technology in actualizing the aims of 'engaged learning' (Chai & Merry, 2006) which necessitates the need for a teacher in the classroom to be well prepared to decide if, when and how technology can, will or should be used. Such technology and curriculum-related decisions create for the teacher a unique set of challenges especially if the teacher's knowledge of technology and its application is limited to basic uses of word processing or Powerpoint™ presentations. Furthermore, the teacher's beliefs (Ertmer, 1999, 2005) and goals play a pivotal role in integrating technology in teaching.

In this paper, we investigate the beliefs, knowledge and attitudes of an experienced primary school teacher as she integrates GS technology in her lessons that seek to employ collaborative and constructivist pedagogies, basing on the concepts of the rapid collaborative knowledge building (RCKB) model (DiGiano, Tatar & Kireyev, 2006). In this exploratory study, we sought to explore the use of the TMG model (Schoenfeld, 2005) as a framing to analyze and explain certain decisions and behavior that Lynn manifested in her classroom. At the end of this case study, we make small but notable assertions about overcoming obstacles in integrating technology as well as building a classroom culture that leverages on technology effectively.

2. THEORETICAL FRAMEWORK

It has been well established that teachers' beliefs plays an important role in influencing teachers' instructional decisions and classroom practices (Pajares, 1992; Ertmer, 1999, 2005; Calderhead, 1996; Cohen, 1990). Aguirre (2000) argues that beliefs play a central role in

teacher's selection and prioritization of goals and actions. Moreover, beliefs shape how teachers perceive and interpret classroom interaction which influences their responses and decision-making processes in the classroom. In essence, beliefs are personal philosophies consisting of conceptions, values and ideologies (Ernest, 1989).

With the view that teacher's beliefs have a profound impact teacher's teaching practices, a series of studies have been done to investigate the relationships between teacher's beliefs and the technology use in classroom. Ertmer (1999) describes two barriers to technology integration, namely, first order barriers and second order barriers. Second-order barriers are intrinsic to the teacher and they include teachers' beliefs which are harder to overcome than first-order extrinsic barriers such as lack of access to software, support and time. Therefore, the teacher's beliefs have to be addressed adequately first in order to have meaningful technology integration. Extending from this, Becker (2000) and Niederhauser & Stoddart (2001) indicated that teachers who had more constructivists beliefs tended to use technology more often than those who held more teacher-centered beliefs. This will be elaborated in the next section.

Goals are what a teacher sets to accomplish in class (Schoenfeld, 2000) and the knowledge of a teacher can be broadly classified into three areas: content knowledge, pedagogical content knowledge and knowledge of the pupils (Bransford, Brown & Cocking, 2000). Such knowledge is related to and hinges on the belief systems of the teacher. In fact, beliefs shape the set of options that the teacher believes to be available to meet those goals and how resources (which include teacher knowledge) are employed (Aguirre, 2000; Schoenfeld, 2000). Thus, there is a complex relationship between the beliefs, goals and knowledge of the teacher in every pedagogical decision that a teacher makes in class. This forms the underlying architecture behind the TMG's (Teacher Model Group) model. The basic idea is that a teacher's decision-making and problem solving is functions of the teachers' knowledge, goals and beliefs (Schoenfeld, 2000, 2005). The teacher enters the classroom with a particular set of goals in mind and some plans for achieving them. Plans are chosen by the teacher on the basis of his or her beliefs. The teacher then sets things in motion and monitors lesson progress. If there are no untoward or unusual events, various goals are satisfied and other goals and activities take their place as planned. If something unusual does take place, then a decision is called for—the teacher will decide whether to set a new goal on the basis of what he or she believes is important at the moment (Schoenfeld, 2005). Schoenfeld and the Teacher Model Group have utilized the TMG model in analyzing, explaining and diagnosing many complex and widely varying teaching episodes (Arcavi & Schoenfeld, 1992; Schoenfeld, 1999; Schoenfeld, Minstrell & van Zee, 2000) at multiple grain sizes. The model has thus proven to be robust (Schoenfeld, 2005). In our exploratory study, we seek then to use the architecture of this model as a framework to analyze and explain certain phenomenon in Lynn's integration of the GS technology in her classroom from a macro-perspective.

3. RESEARCH CONTEXT

As the focus of this study is on analyzing the teacher's personal experiences in using the technology, we adopt a case study approach in mapping out her implementation path (Bielaczyc & Collins, 2006). In the following sections, an account of the context and the teacher and the GS technology is given. This followed by a description of the methods of data collection and analysis.

3.1 Research and intervention context

Lynn is a mature upper primary teacher in the latter stages of a successful career in teaching. Although she is not a graduate, she is currently now a senior teacher with about 40 years of extensive teaching experience in primary schools. In Singapore, senior teachers and master teachers represent the pinnacle appointments for officers on the teaching track, and are recognized for their contributions as highly effective teachers and entrusted with the responsibility of mentoring their colleagues and improving pedagogy and teaching practices in the schools. In contrast with other teachers in her school, Lynn (before our study) is a technology novice, using the computer mainly for grades recording, email communications and word processing. Despite this, she has volunteered to participate in this project and was willing to move up the technology learning curve.

In Singapore, the school year starts in January and ends in November. We started our study in July 2007 working with Lynn and May in their primary (elementary) school in Singapore. Lynn and May teach different classes in elementary grade 4. We started with 6 weeks of Paper Scribbles (PS), which are activities using sticky paper notes, in the classrooms as an initiation phase. This was intentional as a means to begin enculturating the teachers and the students into the practice of rapid collaborative brain-storming and critiquing, and to the relevant protocols and social etiquettes. Easy-to-use sticky notes were adopted to facilitate the students' use in contributing ideas to an activity posed by the teacher. For example, they used sticky notes to guess animals based on the characteristics given by each other, post the name of the organs in the human digestive system, post different living organisms in a particular habitat, and classify fruits according to different characteristics, etc. they used sticky notes to comment on each others' posting as well. In the initiation activities, students worked in group of four. They first posted sticky notes on an A4 size magnetic boards ("group boards") and then put them on the class whiteboard for other groups to see. Sometimes teachers put the group boards under the visualiser in order to let all students see the board at the same time. The groups were pre-formed by the teachers. This worked well as members in groups interacted with one another face-to-face.

Subsequently, the class switched to the use of the GS technology for 10 weeks (Table 1). The students and teachers were provided training for 2 sessions of an hour each. They then used GS for science lessons for another 10 weeks. Each week they had one hour GS Science lesson in the computer laboratory. In our instructional design, we tried to incorporate the following 10 principles, of which the latter five were adapted from Scardamalia (2002):

- distributed cognition – designing for thinking to be distributed across people, tools and artefacts,
- volunteerism – letting learners choose what piece of the activity they want to participate in,
- spontaneous participation – designing for quick, lightweight interaction driven by students themselves,
- multimodal expression – accommodating different modes of expression for different students,
- higher-order thinking – encouraging analysis, synthesis, evaluation, sorting, categorizing, etc.,
- improvable ideas – providing a conducive environment where ideas can be critiqued and made better,
- idea diversity – exploring ideas and related/contrasting ideas, encouraging different ideas,
- epistemic agency – encouraging students to take responsibility for their own and one another's learning,

- democratized knowledge – everybody participates and is a legitimate contributor to knowledge,
- symmetric knowledge advancement – expertise is distributed, and advanced via mutual exchanges.

In Jan 2008, we continue our involvement with the teachers; the students are now in elementary grade 5. In this paper, we focus on Lynn's class. Every week for 10 weeks, two lesson periods (totalling an hour and 10 mins) for the subjects of science and mathematics adopted GS lessons which were conducted in a computer lab. In this class of 40 students, each pupil has an individual Tablet-PC (TPC) with a GS client software installed. In total, we have co-designed, implemented and observed five mathematics lessons and eight science lessons as shown in Table 1 below.

Mathematics lessons	**Mathematics topics**	**Science lessons**	**Science topics**
1	Equivalent fractions	1	Genes
2	Area of a triangle	2	Parts of a flower
3	Division of fractions	3	Plant pollination
4	Ratio of two quantities	4	Seed dispersal
5	Ratio of three quantities	5	Plant reproduction
		6	Stem cutting
		7	Experiment planning
		8	Transfer of energy

Table 1: Topics that were taught in Lynn's mathematics and science class

3.2 GS as a technology that supports RCKB

The motivation for our intervention in the school stems from the realization that there is an ever-increasing need to provide students with learning experiences that reflect the challenges and opportunities they will experience in the workforce of the 21st century. One key class of workforce skills relates to rapid collaborative knowledge building (RCKB). Rapid collaborative knowledge building techniques include problem identification, brainstorming, prioritizing, concept mapping, and action planning (DiGiano, Tatar, & Kireyev, 2006). By harnessing these techniques in the classroom, it is possible for students both to learn existing subject matter more deeply and also to become participants in 21st century knowledge building practices. These techniques can be enacted with light-weight technology such as sticky paper notes (a.k.a. "stickies" or "Post-It" notes or "scribble sheets"), or with digital technologies such as Student Response Systems (SRS). A more sophisticated solution is Group Scribbles (GS), developed by SRI international, which enables collaborative generation, collection and aggregation of ideas through a shared space based upon individual effort and social sharing of notes in graphical and textual form. GS was built on a Tuple Space server interfaced with a client written in Java.

The GS user interface presents each user with a two-paned window. The lower pane is the user's personal work area, or "private board", with a virtual pad of fresh "scribble sheets" on which the user can draw or type (see Figure 1). The essential feature of the GS client is the combination of the private board where students can work individually and group boards or public boards where students can post the work and position it relative to others', view others' work, and take items back to the private board for further elaboration. Figure 1 shows a lesson activity in class in which each pupil posts answers to the question "When does the heart beat faster/slower?" in the private board, and then moves their answers to the public board for sharing. The students' Scribble notes showed a multiplicity of ideas they generated which

enabled the teacher to initiate discussions on the interesting postings. For example, one student posted "just before examination" in the category of "faster heartbeat", a contribution which surprised the teacher and the class, and which prompted the teacher to initiate a discussion on why this might be the case.

In collaborative classrooms, groups of learners and their teachers routinely work in more complex configurations than lecture-based classes. They take roles, contribute ideas, critique each other's work, and together solve aspects of larger problems, all to good effect (Hake, 1998). Managed flow of information and control is essential to the structure of many of these successful educational activities (Guribye, Andreassen, & Wasson, 2003).

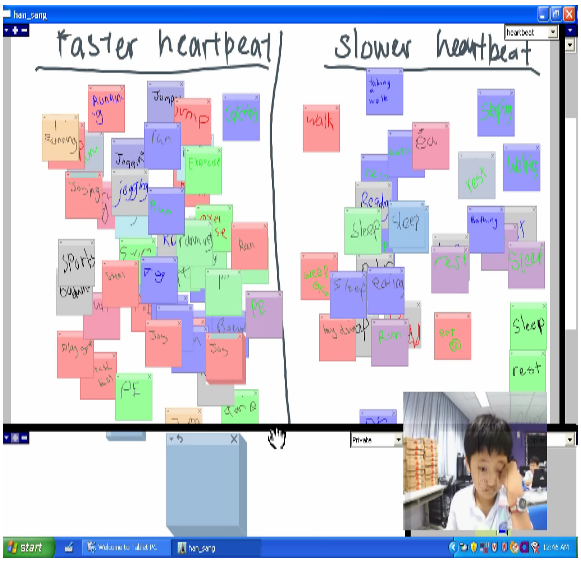


Figure 1: A Morae screenshot of the public or group board (upper pane) and private board (lower pane)

3.3 Data collection

In our collection of data, 2 or more researchers observed each class and took down detailed field observation notes. One video camera was set behind the classroom to record the classroom session, while two other video cameras were focused on two target groups of students. Screen capturing software Morae 2.0 was installed on the TPCs to record the interaction of the pupils using GS. We tried to analyze these videos from different perspectives including uptake analysis (Looi, Chen, Tan, Wen & Wee, 2008), as well as analyze data from surveys, interviews and performance tests (Chen & Looi, 2008). We have also employed semi-structured interview as the method to gain access to the subjective understanding of the teacher. This includes an hour long interview conducted at the end of the semester and weekly post lesson conference sessions. In post lesson conference sessions, both researchers and teacher will discuss about the lesson that has been implemented. In this conference session, researchers will prompt the teacher to reflect on the lesson that has transpired and articulate in the verbal discussion. This proves to be a useful source of data for us as it reveals many subtle beliefs that the teacher hold. The immediacy of the conference session after the lesson, ensures that the teacher do not forget the teaching episodes that they have taught and thus, able to provide good feedback and discussion. These discussions are also used as input to craft the interview questions. In the end of semester interview session, the teacher is interviewed by two researchers with a list of prepared interview questions in a private location. The interview session is audio and video recorded. After the interview session, the interview session is transcribed to create written protocols for analysis.

4. RESULTS

In this section, a discussion on the consistencies of TMG model in explaining the

Lynn's various pivotal decisions to integrate technology into her curriculum. This is done by establishing her beliefs, goals and knowledge in the first instance and then employing them as lenses to explain and understand the various GS-related activities in the classroom.

4.1 Teacher's goals, knowledge and beliefs

Lynn holds several primary beliefs about teaching and learning. Firstly, she believes that as a teacher, patience with the students is very important to help a student learn. She expresses this belief in her own words: "patience with the students is very important to make a child (student) learn. Raising your voice against them will make things worse." This belief is fundamental to other beliefs that she subsequently holds. She firmly believes that addressing the emotional needs of the students is central to students' learning, that in building a good rapport with the students, "the children need to know that teacher understands and cares about them" and that it is important to assure students that it is alright "not to know". Therefore, she believes that students in her class should be comfortable to admit that they have made a mistake and that winning the hearts of the students is important in teaching and learning. Secondly, she believes that "not every student is the same" and that they possess diverse abilities. She also resolves not to let any students in her class to feel "inferior". Students in her class have different strengths and because of these beliefs, she has put in place a collaborative culture that is a suitable for the students to learn from each other. Lastly, she also believes in the importance of teaching "thinking skills in the classroom". This belief motivates her to adopt pedagogies that teach cognitive skills such as posting good comments and designing questions for peer teaching.

On top of these beliefs, Lynn holds beliefs about the use of technology in the classroom. She expressed this succinctly: "it is important to keep up with the times. Nobody forces me to use GS in my classroom. I believe that one must be positive in learning, especially in IT". When asked further, Lynn reflects that this positive mindset is pivotal for her in overcoming obstacles in integrating GS in the classroom in the initial stage and a drive for her to exploit the affordances of GS to the fullest. This intrinsic motivation to learn has led her to be open to changes and has resulted in good working relationship with the research staff.

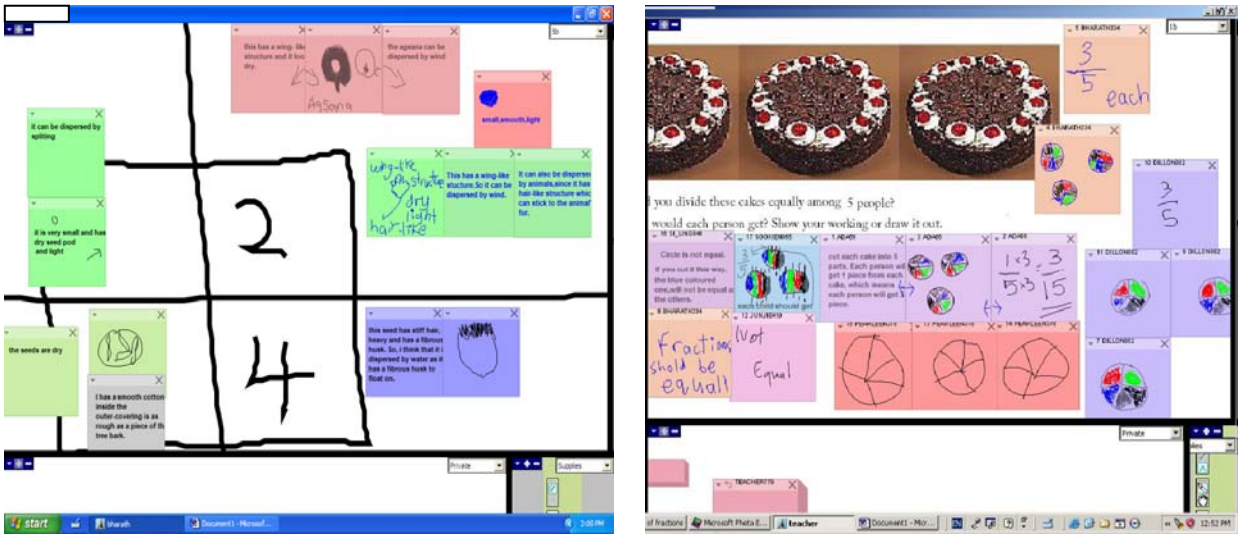
Closely linked to her beliefs are her "overarching" goals (Schoenfeld, 2000) in integrating GS technology in her classroom. In the interview with Lynn, she expressed that her main goal is "to see her children (students) learn because this gives a lot of satisfaction" to her. In a conversation with her Head of Department, he adds that Lynn took up GS technology because "it is an opportunity for her to build up her portfolio as a senior teacher as she is competing with another senior teacher". We tend to infer that Lynn may hold two overarching goals but her beliefs about teaching and learning, may have helped her to prioritize the goal of "seeing her children (students) learn" as a more important goal. Her beliefs have also provided a focus for Lynn to select knowledge appropriately for effective learning. Because of her long teaching career, Lynn possesses reasonable good content and pedagogical content knowledge of her teaching subjects - Mathematics and Science. This is confirmed in the separate interviews with her students, Bala[1] and Yanni[1] who unanimously confirm that she is a "knowledgeable teacher who is correct most of the time". They also comment that they "enjoyed her lessons and were able to understand what she is teaching". Because of her strong belief that every child is able to learn, she has devised lessons that were relevant to the students and were able to leverage the affordances of GS to her advantage. This will be further elaborated in the next section.

4.2 Implementing GS technology in the classroom

This section describes selected teaching episodes which shows coherency between the Lynn's beliefs, goals and knowledge and the affordances of the GS technology.

4.2.1 Multimodal expressions in GS

In many of Lynn's science lessons (lessons 1-5, 8; see Table 1), "live" specimens were used for students to sense and observe. For example, she has brought plant seeds for lesson 4 and flowers for lessons 2 and 3. By allowing students to observe and sense the specimens, the different learning styles (Visual, Tactile, Kinesthetic and Audio) of every student were catered. This stems from her belief that every student learns differently, as mentioned in section 4.1. This belief also caused the teacher to leverage the affordance of GS which allow students to express their answers on the pad in different written forms—drawing or typing. This has produced a rich variety of answers, as shown in Figure 2. In Figure 2a, some students prefer to draw and color while the tactile students prefer to type. Some highly kinesthetic students prefer not to post anything but verbalize their answers during the lesson. Similarly in mathematics lessons, different students articulate their answers in different modes as shown in Figure 3. In a nutshell, Lynn's belief in the diverse abilities and learning styles among her students, motivates her to plan and implement lessons that cater to different learning styles of her pupils. In this way, the multimodal affordance of GS is leveraged.



2(a) 2(b)

Figure 2: Multimodal expressions in a) Science lesson; b) Mathematics lesson

4.2.2 Creating a conducive collaboration environment

Lynn's student-centered beliefs enable her to create an environment that promotes collaborative learning. In section 4.1, she expressed one of her major belief as "patience with the students is very important to make a child learn. Raising your voice against them will make things worse." In her lessons, students are allowed to express their answers without fear of criticism. This is not only seen in verbal articulation but also in the written ideas on GS boards. Students are taught by Lynn to give constructive comments so that students' self esteem would not be harm. Praises are given as much as possible by Lynn and very few incidences of chiding are observed. In addition, her other belief in the diverse abilities among her students causes her to value every view that her students articulated. Thus, she implements group collaborative learning because she believes it is a good avenue for every student to build upon each other knowledge. With these beliefs and culture in place, GS affordances are leveraged effectively. Students and teachers believe that collaboration maximizes learning and thus, more willing to exploit the features of GS technology that supports collaborative learning e.g. viewing other group boards, peer reviewing each other ideas, posting ideas in real time etc. These affordances

are leveraged successfully in promoting collaborative learning. Because of these reasons, we could observe substantial collaborative results e.g. evidences of peer learning and critique, higher order thinking skills, richer content etc due to the collaborative culture that she has build in the class. This is reported elsewhere in detail (Looi, Chen, Tan, Wen & Wee, 2008). Consequently, this builds up the confidence of both the teacher and students, and increases their willingness to explore other features of GS as well that may not be used in the lessons.

In sum, Lynn has a positive attitude towards integrating GS technology in the classroom in the first instance because she perceives the coherency between the affordances of GS technology and her beliefs. This kick-starts an iterative process of the progressive development of better lessons that can leverage well on GS affordances based on personal reflections, lesson co-design sessions with the researchers, and professional development sessions with her colleague and researchers. The positive experiences that she gained after every lesson, serve to reinforce her beliefs further. This iterative process of action research strengthens her convictions about collaborative learning and appropriateness of GS technology in teaching.

4.2.3 Dealing with technical glitches

The confidence and willingness to exploit technology allows the teacher and students to deal with occasional technical glitches in the GS technology. Instead of losing faith in the technology, Lynn continues to use the technology in the classroom and makes efforts to deal with the technical glitches. This is done by in two ways:

- Lynn tries to find ways to minimize similar glitches from occurring, e.g. minimizing the risk of the computer system "hanging" by not loading background pictures which slows down the system. Although this may mean extra considerations in planning the lesson, Lynn is willing to accommodate these changes.
- Lynn has also found ways to found "filler" activities, in the event that GS technology fails. This includes switching to alternative technologies e.g. Windows Journal, group presentations and using sticky notes pads.

4.3 Teacher's support and professional development

The success of technology integration in the classroom ultimately depends on the teacher's commitment to be a pioneer (Mitchell, Bailey and Monroe, 2007). In addition, Dwyer, Ringstaff and Sandholtz (1990) reported that the development of teachers in integrating technology requires a level of teacher support and professional development. In Lynn's case, her commitment to be one of the first teachers in the school to use GS is strongly rooted in her belief about "keeping up with the times" and "positive in learning, especially in IT" as mentioned in section 4.1. Her commitment and belief has also allowed her to learn from and build good rapport with the researchers. Her positive learning attitude has enabled her to participate actively in our initial enculturation and GS training programmes using Paper Scribbles (Ng, Looi & Chen, 2008). In addition, we have also conducted periodic professional development (PD) sessions for the teachers. These serve as avenues to communicate good practices to teachers via videos, gather feedback from teachers as well as refining future lesson plans to meet both learning objectives for the class as well as our research objectives. Lynn comments that "videos of her lesson is good for her development" and subsequently "helps her to plan better lessons". More importantly, PD sessions have strengthened the relationship between teachers and researchers such that Lynn is more receptive to changes and we are able to understand better the workload constraints placed upon the teachers. In Lynn's own words after the first PD session: "Thank you for your guidance and kindness in your actions and words too. We sincerely enjoyed working with you." In sum, the support shown to Lynn, via PD, technical support and good working with researchers have enabled her to develop competencies in integrating GS in her classroom. As a visible sign of her achievement, Lynn is

appointed the school's representative to train other teachers both in her school and her cluster schools to use GS after eight months of integrating GS in her lessons. In addition, she has confidently commented that she will "continue to use GS in her lessons even after the end of the collaboration."

5. DISCUSSION

In this section, the findings are summarized to give an insight to teacher's developmental trajectory in integrating GS technology in the classroom, based on this exploratory study. The coherency between the teacher's knowledge, goals and beliefs and the affordances of the technology is the main key in integrating technology effectively in the classroom. This is important in the different implementation phases of the technology: the initial phase, the implementation phase and the maturation phase.

In the initial phase, the teacher must be convinced both affectively and cognitively to accept the technology into the classroom. The perceived affordances of the technology, in the context of the classroom that the teacher teaches must align with the beliefs, goals and knowledge of the teacher. The teacher must be able to perceive himself as a capable user of the technology. Therefore, it is important for the teacher to articulate their beliefs, goals and knowledge as well as their perception of the technology at this stage to minimize any misconceptions. In our case study, the affordances of GS technology rest firmly on the student-centered RCKB principles. Lynn perceived these affordances to be congruent with her student-centered beliefs and goals. The affordances of GS technology complement and enhance her knowledge of content, pedagogy and her class. For example, the features of GS technology would allow her to teach science lessons better in a collaborative setting. In addition, although she is technology novice, the user-friendliness features of GS gave her the confidence that she is able to learn it well later. If there is a mismatch between the two, the teacher may not be convinced to leverage the technology fully or even accept the technology at all.

In the implementation phase, the teacher proceeds to use technology in the classroom lessons. This is a critical stage because the perceived coherency between teacher's beliefs, goals and knowledge and affordances of technology is enacted in real classroom lessons. If the implementation of the technology in the first few lessons fulfills the goal of the teacher, there will be an increase in confidence in the technology. In this stage, immediate responses from the students and feedbacks from research team, head of departments and fellow teachers play an important role in affirming teacher's confidence. This increase in confidence provides an additional motivating platform to leverage the technology more in the future. Interestingly, this also affects the students' confidence in using the technology too. Thus, there exists a cyclical relationship between research staff, superiors, students and teacher where one will affirm the other in integrating technology. In our case study, Lynn obtained positive responses from her students as well as encouraging feedbacks from the research team as well as her head of department during the first few lessons. She was able then to use the GS technology in her lesson more confidently and further convince her students about the benefits of the technology.

In the maturation phase, teacher has garnered enough positive experiences to use the technology despite technical glitches in the technology. Not only that, the teacher has become more aware of the strengths and weaknesses of the technology which allow her to appropriate the technology better. The coherency between the teacher's goals, beliefs and knowledge and the affordances of the technology has been strengthened by the positive experiences accumulated over time. With new knowledge of the technology and increased confidence, the teacher will persist in the integrating of technology despite technical glitches.

6. CONCLUSION

In this exploratory study, we attempt to use the TMG model to analyze the teacher's developmental trajectories in integrating GS technology. Our results show that the coherency between teacher's beliefs, goals and knowledge and the affordances of the technology is the main key in leveraging the technology successfully. In our findings, we classify the developmental trajectories into three phases - initial, implementation and maturation phases where we explore the different interplay mechanisms between the teacher's beliefs, goals and knowledge and the affordances of the technology. In the maturation phase, the teacher is the most capable in dealing with any problems that may arise in using the technology both affectively and cognitively. As this is an ongoing work, we will continue to analyze more case studies and further develop the key ideas addressed in this paper.

Acknowledgements

This material is based on work supported by a grant from the National Research Foundation, Singapore. We wish to thank SRI International for providing a license to use the GS software in Singapore and members of our GS team for sharing their valuable insights and perspectives with us. We are grateful to Mayflower Primary School for collaborating with us on this research.

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