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# SCHOOL-BASED RESEARCH IN GROUP SCRIBBLES: SUSTAINING AND CREATING IMPACT IN SCHOOLS

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**Abstract:** Effectively integrating and sustaining the use of technology in classroom practices is always a challenge. Our intervention project helps schools adopt a light-weight technology called GroupScribbles (GS) by collaborating with a primary school from 2007-2009 and scaling up to two secondary schools in 2009. In these collaborations, we have worked with nine teachers, three heads of IT departments and three technical assistants in integrating GS technology lessons into the school curriculum. GS lessons have been implemented in Secondary School subjects i.e. Mathematics, Chinese, Higher Chinese, Physics and in Primary School subjects i.e. Science, Mathematics, Chinese and Higher Chinese. We will report the opportunities and challenges that we as researchers faced as we tried to implement technology in the classroom. Some of the wide-ranging challenges include technical problem, attitudes of teachers and school leaders, teachers' pedagogy and students' learning (TAPS). More importantly, we will give accounts of how researchers and schools have established mutually beneficial collaborative relationships during the various stages of the research encompassed within the School-based Research Framework (SRF). These stages include the introduction stage, setup stage, enculturation stage, lesson implementation and professional sharing stage and the eventual independence stage. For sustained innovation in schools, teachers and school leaders play a pivotal role.

**Keywords:** Rapid collaborative knowledge building, ICT in schools.

## 1. INTRODUCTION

We live in an increasingly technology-embedded complex world, where collaborative skills, rapid sharing of ideas, communication and innovation is the order of the day. By contrast, many school systems around the world are still struggling with teaching students facts and procedures by rote, while the world has moved on quickly and hardly waits for educational systems to catch up. The most typical or default pattern of classroom interaction is the IRE (initiation-response-evaluation) pattern which has been shown to account for a possible 70% of

teacher-student classroom interactions (Nassaji & Wells, 2000). In the IRE, a teacher initiate questions or discussions (I) is followed by a student reply (R), followed by an evaluation of this reply (E) by the teacher. IRE has been criticized for leading to unrewarding and boring classroom discussions. Changing such deep-seated traditional patterns of classroom discourse poses a considerable degree of challenge for classroom reform. Moreover, 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). RCKB 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. “PaperScribbles (PS)” or “Post-It” notes or “scribble sheets”), or with digital technologies such as Student Response Systems (SRS). In PS, 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. In addition, they used sticky notes to comment on each others’ posting as well. 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.

## 2. GROUPSCRIBBLES AS A TECHNOLOGY SUPPORT FOR RKCB

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 student 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 state 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

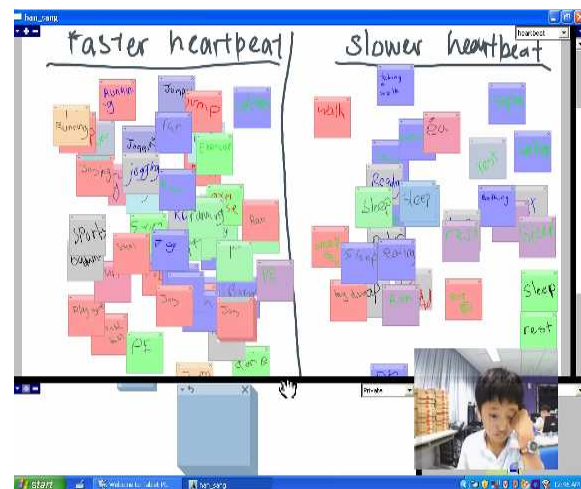


Figure 1 : A Morae screenshot of the public or group board (upper pane) and private board (lower pane)

educational activities (Guribye, Andreassen, & Wasson, 2003).

### **3. RESEARCH CONTEXT**

#### *3.1 Research and intervention context in schools*

We conducted our GS intervention project in one primary school from the later half of 2007 till first half of 2009 and two secondary schools for the whole of 2009. In these schools, we implemented the School-based Research Framework (SRF) to ensure fruitful research collaboration between researchers and the schools as well as increasing the probability of eventual sustainability and scalability of GS usage among these schools and beyond. In our intervention project, we co-design GS lesson plans with teachers at the appropriate stages where we try to incorporate the following 10 principles of RCKB (Ng, Looi, & Chen 2008), 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.

### *3.2 School-based Research Framework (SRF)-Stages in intervention*

The SRF follows a series of sequential stages in the implementation of GS in the schools. As researchers, we believe that the use of GS is not merely a technical add-on but a transformation of class culture and pedagogy. This also includes a change in teachers' beliefs, knowledge and goals (Chen & Looi, 2008; Chen, Looi & Chen, 2009). Hence, SRF provides a structured framework by which these transformations can occur. These stages include introduction stage, setup stage, enculturation stage, lesson implementation and professional sharing stage and the independence stage. At each stage, the Technical, Attitudes of teachers and school leaders towards GS technology, Pedagogical, Students learning (TAPS) variables serve as evaluation instrument for progression to the next stage.

The technical variable broadly refers to the technical infrastructure required and technical competency levels of teachers, students and technical assistant (TA). The pedagogical

variable refers to the dominant pedagogy used in the classrooms where it is closely tied to the school curriculum, teacher's attitudes toward technology and dominant assessment modes. The attitudes of teachers and school leaders towards the technology involve one's beliefs, knowledge and goals in leveraging the affordances of the technology in the classroom. The complex mechanism is reported in other papers (Chen & Looi, 2008; Chen, Looi, & Chen, 2009). Students learning denote how effectively a student has learned in the classroom. This may involve precursors to classroom learning such as acquiring basic technical competency in the technology and knowing how to engage in effective collaborative group work in a GS-enabled lesson.

In the introduction stage, researchers introduce the technology to schools leaders and teachers. This may be done via an ICT seminar, lesson observations or formal discussions between researchers and school personnel involved. The primary objective is to expose schools to the affordances of the technology as well as to communicate the research purposes in the collaboration. Researchers need to select relevant affordances of the technology that meets the needs of the school curriculum which leverage IT effectively on a long term basis. These should form the eventual goals of the school. Hence, TAPS variables are used to identify gaps between the school's current status and researcher's ideal goals. Thereafter, a systematic and realistic framework in the form of SRF aims to close the gaps identified as much as possible. This includes explicit communication of research purposes, technical requirements and expectations of teachers, in order for school leaders and teachers to weigh the pros and cons appropriately to make an informed decision to commit.

In the setup stage, researchers collaborate with school technical personnel to set up basic technical infrastructure to implement the technology. At this stage, it would be appropriate if the

school can identify a staff member (usually a Head-of-Department) who can spearhead the collaboration. Thereafter, relevant technical equipment needs to be purchased and installed appropriately. At this juncture, school's technical personnel should be actively involved in the setup to learn about the technical aspects of the technology. This helps in sustainability and scalability efforts later on.

After the setup stage is completed, training and enculturation activities are planned for teachers and students. Koehler (2007) states that Schulmann's (1987) pedagogical content knowledge (PCK) must be established prior to the technological pedagogical content knowledge (TPCK). Thus, we believe that developing new pedagogical competencies should be prior to and take precedence over, the technical competencies of the technology. This stage is particularly important if the school's primary pedagogical mode deviates from the new pedagogy advocated by the technology. The developmental progression should be gradual and incremental in nature to avoid "cognitive overload" (Sweller, 1988). The enculturation stage acts a transitional phase before the actual implementation of technology in the classroom. For our case, the enculturation stage is intended to enculturate the teachers and the students into the practice of rapid collaborative brain-storming and critiquing and to the relevant protocols and social etiquettes of RCKB. Separate technical training sessions are provided for teachers and students for initial training on technical competency. It is important that the technology is user-friendly so that staff and students are motivated to use the technology in this first exposure. To offload any technical competencies problems, the first few enculturation activities should use a similar yet intuitive pedagogical tool that could enculturate students and teachers into the pedagogy supported by the technology. For GS, the alternative technology is PS as described in the preceding sections. It would also be helpful if the enculturation activities could be carried out



within a non-assessable curriculum. In this way, students and teachers are offloaded from the stress of performance. Fun work should be included in the activities to increase motivation to use the technology. Core benefits of this new pedagogy should be demonstrated during the first few enculturation activities in order to motivate teachers and students to use the technology later on. In addition, the stage would also allow researchers and teachers to co-design lesson plans in a “non-formal” setting that is free of curriculum and assessment constraints so that a certain rapport can be built between teachers and researchers. The number of enculturation sessions should be flexible and carried out till a certain TAPS level is achieved.

Lesson implementation stage forms the core of the SRF. At this stage, teachers implement the technology within school based examinable curriculum. It is important that the transition from enculturation to lesson implementation stage should be kept as smooth as possible. The smoother the transition, the better would the technology be leveraged in the classroom. This could be done by keeping the non-assessment based curriculum content as close to the actual lesson curriculum as possible. Lesson plans are co-designed between teachers and researchers so that teachers could learn from researchers innovative lesson plans that leverage the affordances effectively in the lesson. This stage takes time to proceed and it occurs in iterations. At this stage, it is important that the affordances of the technology and the research objectives are known to all parties involved.

Professional sharing stage encompasses professional sharing sessions interspersed between lesson observations after a minimum relevant number of technology-based lessons have been enacted. This allows researchers and teachers to share good practices and areas of improvements with teachers involved. These sessions also provide another avenue for teachers, school leaders and researchers to feedback to one another about the progress of the research

project and the use of the technology in class. These sessions are pivotal in establishing good communication channels between all three parties. In the scenario where multiple schools are involved in the same project, professional sharing sessions provides opportunities for teachers from different schools to gather together and share good practices with one another. These help to form “community of practice” (Lave & Wenger, 1991) among teachers which aids in sustainability later. A possible extension is to involve students in the professional sharing sessions as well.

The SRF culminates in the independence stage. At this stage, schools are ready to use the technology without researchers’ support. Again, this encompasses TAPS domains. In the technical domain, teachers have acquired a certain level of technical competencies in using the technology comfortably in the classroom. This include troubleshooting common technical glitches and setting up basic technical configurations for the lessons. School technical assistants would have acquired advanced technical skills in handling both the software and hardware of the technology, allowing them to support the teachers effectively and independently. In the pedagogical domain, teachers internalized the affordances of the technology and are able to leverage the technology effectively and appropriately in the classroom. In the attitudes of teachers and school leaders and students’ learning domain, there should be now a substantive positive shift towards the new culture of learning and teaching using the technology. School leaders, teachers, students and parents should be convince of the benefits of using the technology in the classroom and are willing to use the technology continually in the classroom. This comes from the accumulation of positive experiences from the previous stages in the SRF.

This paper will discuss the challenges that researchers, teachers and students faced at the different stages of SRF and how are the challenges resolved at each stage of the SRF.

## **4. RESULTS AND DISCUSSION**

### *4.1 MF primary school*

#### a) SRF implementation charts for the schools

We started our study in July 2007 working with two teachers (Teachers L and M) in MF primary (elementary) school in Singapore. Both teachers teach different classes in elementary grade 4. One class consists of high ability students (Class H) while the other consists of average ability students (Class A). Teacher L teaches Class H while teacher M teaches Class A. We started with 6 weeks of Paper Scribbles (PS), which are activities using sticky paper notes, in the classrooms as the enculturation stage. Prior to this stage, we spent about 2 months introducing GS technology to the school (introduction stage) and setting up the necessary technical infrastructure (setup stage). In each class of approximately 40 students, each pupil has an individual Tablet-PC (TPC) with a GS client software installed. The school has designated a technical assistant (TA) to learn GS technology as part of their sustainability efforts by assisting us in technical issues with the school's equipment. The students and teachers were also provided with technical training for 2 sessions of an hour each. Subsequently, they implemented GS for science lessons for about 10 weeks in the lesson implementation stage. Each week they had one hour GS Science lesson in the computer laboratory.

From Jan to Oct 2008, we continue our research with the two more Chinese teachers (Teachers D and I); the students are now in elementary grade 5. Every week for 10 weeks, two lesson periods (totaling an hour and 10 minutes) for the subjects of science (for 2 semesters), Chinese (for 1 semester), Higher Chinese (2 semesters) and mathematics (for 1 semester) adopted GS lessons which were conducted in a computer lab. Teacher D teaches Class H Higher Chinese while Teacher I teaches Class A Chinese. We ended our intervention on Apr 2009.

From Jan to Apr 2009, we scoped down our research to only one class (Class H) with one teacher (Teacher DH) and one subject of science. At this time, students are now in elementary grade 6. Throughout the lesson implementation stage from Jan 2008-Apr 2009, several professional sharing sessions have been organized for the teachers involved in the collaboration. These SRF implementation chart for MF Primary School are summarized in the Table 1 below:

Period	May-June 2007	July-Aug 2007 (6 weeks)	Aug 2007-Dec 2007	Jan 2008-June 2008	Jul 2008- Dec 2008	Jan 2009-Apr 2009	Beyond Apr 2009	
Class H	Introduction and setup stages	Enculturation stage	Lesson implementation stage-Science	Lesson implementation stage-Science and Maths	-Lesson implementation stage-Science -Professional sharing stage	Lesson implementation stage-Science	Independence stage	
Class A						Independence stage		
Teacher L								
Teacher E								
Teacher DH		Not Involved					Lesson implementation stage-Science	Independence stage
Teacher I		Not involved			Technical training+Lesson implementation stage-Chinese and Higher Chinese	Not involved	Not involved, teachers has left the school	
Teacher D		Not involved				-Lesson implementation stage-Higher Chinese -Professional sharing stage		

Table 1: SRF implementation chart for MF Primary School (students and teachers)

#### b) Challenges and resolutions at the various stages of the SRF

At the introduction stage, we communicated relevant affordances of GS technology and how these can help to create a niche for the school. We cited success stories of GS and how these can be implemented in M Primary School. Prior to meeting the school personnel, the

researchers had done some homework to find out the school's current TAPS status. In this way, we devised ways to bridge the gaps in these areas. Thereafter the researchers gave the school a firm assurance of our support and how this support can be given systematically to the school in accordance to the SRF structure. More importantly, we informed the school about the high possibility of sustained implementation of GS technology in the school after the end of the intervention project. In essence, the SRF structure presents GS collaboration as a profitable investment i.e. money, time, manpower to the school. With this, we secured the enthusiastic support from the Principal and the Head-of-Department (HOD/IT) for IT was designated to spearhead this collaboration with us. As a show of their support, teachers selected for the project were offloaded to certain extent from their normal teaching duties.

We then proceeded to setup the necessary technical infrastructure for the school. In line with our sustainability efforts, we included the TAs and HOD/IT in the planning and implementation in the setup stage. As we inspect the initial technical infrastructure of the school, there was much equipment that the school needs to purchase to implement the technology effectively. As the Principal's support was secured in the introduction stage, the additional equipment was procured easily. In addition, a physical reconfiguration of the computer laboratory was carried out e.g. relaying of cables, rearranging seats and tables etc. All these work is in line with TAPS categories. There were setting up of technical infrastructure alongside with acquiring of technical skills by the TAs and HOD/IT. The attitudes of TAs and HOD/IT toward the technology took a even more positive change with intentional support efforts from the researchers. It must be emphasized that these "first impressions" formed are important for subsequent work. Moreover, detailed planning for implementing GS technology

into the present curriculum was also carried out. The whole process took about one to two months to complete.

In the subsequent enculturation stage, the new RCKB pedagogy is introduced. This stage concentrated particularly on the pedagogical and student learning aspects within the TAPS categories. As dominant pedagogy was didactical in M Primary school, 6 weeks of enculturation activities were co-designed by teachers and researchers to gradually implement 10 principles of RCKB pedagogy. In the first few lessons, researchers took lead in designing enculturation lessons. In this way, teachers observed and learn from researchers how to design lesson plans that encompass 10 principles of RCKB. Subsequently, teachers took lead in designing of lesson plans with appropriate scaffolding from researchers. As this is the first time that researchers and teachers collaborate, the enculturation provided an informal platform for both parties to know each other schedules, working styles and objectives. As we wanted to concentrate on the pedagogical aspect, we introduced RCKB pedagogy using PaperScribbles (PS) instead of GS. In PS, easy-to-use sticky notes were adopted to facilitate the students' use in contributing ideas to an activity posed by the teacher. We also allocated time slots outside curriculum time to implement these lesson activities. In this way, the content of the enculturation activities is free from curricular and examinations constraints for e.g. time-table, designated content. By offloading the teachers and students from the burden of technical “know-how” of GS technology and curriculum constraints, teachers and students can concentrate on developing this new RCKB pedagogy in their classroom in a gradual but fun way. Using familiar context of fruits (shown in Figure 2), Terry Fox and Spider man, students were taught how to post and comment each other ideas in a constructive manner, classify and organize their posts in a logical fashion exemplified in Figure 3. For smooth transition to the next lesson implementation stage,

the final lesson was based on the topic of Habitats so as to keep close to the science curriculum as possible. Hence, as the activities were fun, familiar and easy, students master the enculturation's learning objectives without much difficulty. We also discover that, not only pedagogical and student learning aspects were accomplished but the attitudes of teachers and students (TAPS) took a positive impression of GS technology. With this, students and teachers waited in eager anticipation of GS lessons.



Figure 2: Students in an enculturation activity based on the theme of Fruits

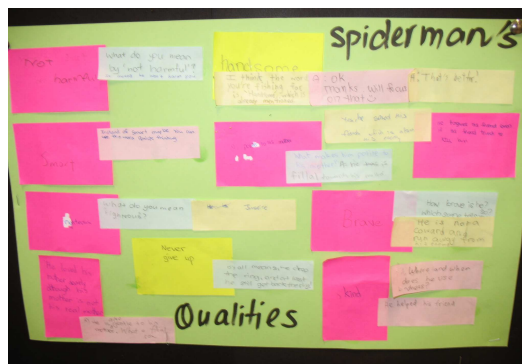


Figure 3: A sample of a PS group board based on the theme of Spider Man

The successful implementation of the preceding stages has equipped students, teachers, TAs and HOD/IT to a basic proficiency level in the various TAPS categories for smooth implementation in the lesson implementation stage. In this stage, we faced a number of

challenges. These challenges can be grouped according to the TAPS categories. One major technical challenge includes resolving unanticipated technical glitches in the GS technology particularly in the early phases of this stage. As the curriculum time for every GS lessons was short, technical glitches in the GS technology often took away precious time from the lesson itself. This causes undue interruptions in the lesson flow and the collection of data. To overcome these challenges, researchers and teachers have designed a set of “filler” activities for students to engage in the event of glitches in the GS technology. Some examples of “filler” activities include changing to alternative worksheet activities and using substitute technologies such as Windows Journal. Simple quick fix solutions were also taught to the teachers and students. For example, if the GS technology hangs in the middle of the lesson, teachers and students could restart the software on their own without waiting for the TA or the researcher to come to their aid. In addition, we have learnt to give “buffer” time in our lesson planning for technical glitches. In this way, researchers and teachers are mentally prepared for any technical problems that may arise. In addition, the design of the GS software went through iterative cycles where in-house programmers rewrite and redesign the source code in responses to any software bugs and errors that occurs during the lesson itself. In this way, technical glitches were kept at bay and accountability is given to the school. More importantly, researchers give psychological support in the form of encouragement, technical support and assurance to the teachers, students and HOD/IT whenever they are discouraged. For example, researchers praised teachers and students for any successful lessons implementation and provide realistic suggestions to solve technical issues that arise in the lesson. In view of this, post lesson conferencing and professional sharing sessions provided appropriate avenues for these to take place.



With regards to pedagogical challenges, a teacher-centered approach was adopted. This is because teachers play a central role in the sustainability efforts. In this stage, teachers predominantly planned lessons on their own with appropriate scaffolding from researchers. After discussing with researchers, teachers planned and designed a draft of the lesson plan one and half weeks before the actual lesson. Researchers vet through the lesson plans and give suggestions to improve the lesson plan. In this way, teachers “own” the lessons as they design GS-enabled lessons based on their knowledge, goals and beliefs (Chen & Looi, 2008; Chen, Looi & Chen, 2009) about their students’ profiles, curriculum and the GS technology. In M Primary school, Teachers L and E were encouraged to help each other draft out suitable lesson plans for their classes. In this way, both teachers complemented each other in terms of their strengths and weaknesses to plan an optimum lesson plan. Sometimes researchers have to compromise within the limits of the research objects in order to match teachers’ competencies and confidence level. For example, researchers would like to collect data on how new concepts can be introduce to the students via RCKB. However, teachers indicated that they were not confident in teaching new concepts using GS. Hence, in line with our teacher-centric approach, researchers modify the lesson plan requirements to allow certain degree of didactic teaching for introduction of new concepts. In this way, the positive outlook towards GS technology is maintained. However, as teachers acquired better competencies in RCKB pedagogy and GS , we gradually decrease the didactic teaching component in the lesson plans. With good progress in Technical, Pedagogy and Attitudes aspects, students’ learning naturally falls into place. Students of both Class H and A exhibited higher motivation to learn in a GS- enabled lesson and acquired skills of RCKB gradually for effective collaboration to take place. Below is an excerpt of a

thank-you speech (at the end of our collaboration) given by the student class representative of Class H that illustrates the how motivation to learn in a GS-enabled lesson:

Class Representative Class H: You (researchers) have helped developed GroupScribbles into something that our class loves and you have made our lessons fun and enjoyable. If not for you, we will still be doing nothing but study!

After teachers have garnered adequate GS experiences, professional sharing (PS) sessions were planned monthly in semester 2, 2008. These sessions provided avenues for researchers, teachers and HOD/IT to interact, share and discuss their experiences in GS. Although Teachers L and M may collaborate to design the lesson plan, they have not observed each other lessons. Selected recordings done by the researchers of their lesson were shown during these sessions to share good practices in the classroom. These have shown to help teachers to reflect on their lessons as well as to affirm the teachers of their hard work. As the school was supportive of our collaboration, teachers were excused from all meetings during the designated PS timeslots. Below is an excerpt of an interview with Teacher E to illustrate how a video in a PS session has caused her to be more aware of her shortcomings.

Researcher: Does Groupscribbles affect your classroom management?

Teacher E: After watching the video recordings of GS lesson, it (GS) made me aware of my shortcomings and I tell myself that I've to change. I went back and I thought about it: "Why do I talk to students this way?"

During the course of the intervention project, we see teachers joining and leaving the project at different points of the project, shown in Table 1. Teachers D and I joined this project in 2008 after one semester has passed in 2007. Teachers L and M left the project at the end of 2008 while teacher DH took over teacher L as the Science teacher for Class H in 2009. Although teachers D, I and DH did not participate in the enculturation stage, the disruptions to the research progress were surprisingly minimal. We attributed these to two factors: firstly, students of classes H and A were already competent technically and pedagogically to a certain

level when the teachers first joined them. These motivated the teachers to quickly learn the essentials of the GS technology. Secondly, teachers L and M provided teachers' support to these teachers according to the TAPS areas. Although researchers provided necessary support, these factors provided the main impetus for the quick adaptation to the GS technology. This was distinctly apparent for Teacher DH she took over a highly enculturated Class H in 2009. It was interesting to note that, Teacher DH displayed most rapid growth among the group of teachers involved with GS, given the short time frame that she has collaborated with us.

### c) Sustainability and scalability

The culmination stage in the SRF is the independence stage. It is shown in table 1 that teachers and classes transit to the independence stage at different points of the intervention project as part of the school's sustainability and scalability efforts. Teacher L took over as Head-of-Level in 2009 to spearhead GS for the whole of primary three under the MAPLE (M Primary Literacy Excellence Programme) Programme. Teacher L has been tasked to train primary three teachers and students to use GS as well as to co-design GS-enabled lessons for the English subject. To date, seven classes and six teachers have been involved. These were done at minimal guidance from the researchers. Teacher M has been tasked to assist in training and helping other primary five teachers in implementing GS for the subject of Science for six classes involving five teachers. The HOD/IT designed and conducted technical training programs suited for the curriculum at each level. Moreover, the school plans to implement GS to primary two and four levels. Designated teachers from primary three to five were also asked to observe Class H and A GS lessons as part of the training. In addition, the school intended to augment GS technology from wired to wireless configuration as well as purchasing UMPCs (Ultra Mobile Personal

Computers) for GS mobile learning in the future. It is noteworthy to emphasize here that all these initiatives occur without any intervention from the researchers.

From this longitudinal case study, we can make some assertions about scalability and sustainability of IT in schools. Firstly, teachers play a central role in the implementation of technology on a long-term basis. A teacher-centric approach must be adopted in all stages of the SRF for sustainability and scalability to occur. It is important to adopt incremental shifts instead of big shifts. Secondly, enculturation stage serves as an important transitory stage for smooth integration of technology. Thirdly, practical support from school leaders e.g. offloading teachers' workload, purchasing equipment is critical to the implementation plan. Lastly, a class of competent and enculturated students provide an added motivational impetus for teachers and other students to adopt the technology in the classroom. TAPS provided a set of categories to analyze the effectiveness of each stage.

#### 4.2 Scale up of GS project to secondary schools

We have not only scaled up the GS project horizontally to other classes in M Primary School but also vertically to two secondary schools (W and F secondary schools) successfully in 2009. We started our collaboration in Oct 2008 and we have adopted the SRF framework in these schools. In W secondary school, we collaborated with two teachers (Teacher Y and Teacher S) in two subjects- Chinese and Physics. Both teachers teach the same secondary three classes (Class S3). Similarly, in F secondary school, we collaborated with two teachers (Teacher A and Teacher J) in two subjects-Higher Chinese and Mathematics. However, these teachers teach different classes of different levels. Teacher A teaches Higher Chinese in a secondary two class (Class S2) while Teacher J teaches Mathematics in a secondary one class (Class S1). In

each class of approximately 40 students, each pupil has an individual Tablet-PC (TPC) with a GS client software installed. The schools have also designated a technical assistant (TA) or ICT executive to learn GS technology from us as part of their sustainability efforts as well as assisting us in any technical issues with the schools' equipment. The students and teachers were also provided with technical training for 2 sessions of an hour each. On average, each school has about 5 to 6 weeks (Jan 2009-Mar 2009) of enculturation. Due to the long time table and heavy academic content in secondary schools, enculturation sessions have to be infused into the main curriculum. Subsequently in the lesson implementation stage, we implemented GS for each subject for about 5 to 6 weeks so far (Mar 2009 to Apr 2009) in academic term 2. Each week they had one hour GS for each subject lesson in the computer laboratory. It is noteworthy here to state that wireless network configuration was set up for F secondary school while wired network was used for W secondary school. These SRF implementation chart for both secondary schools are summarized in the Table 2 and 3 shown below.

Period	Oct 2008	Nov 2008-Dec 2008	Jan 2009-Mar 2009	Mar 2009-Sep 2009	Beyond Sep 2009
Class S1	Introduction Stage	Setup stage	Enculturation stage	Lesson implementation stage- Higher Chinese and Mathematics	Independence stage (*not implemented yet)
Class S2					
Teacher J					
Teacher A					

Table 2: SRF implementation chart for F Secondary School (students and teachers)

Period	Oct 2008	Nov 2008-Dec 2008	Jan 2009-Mar 2009	Mar 2009-June 2009	July 2009-Sep 2009	Beyond Sep 2009
Class S3	Introduction Stage	Setup stage	Enculturation stage	Lesson implementation stage-Chinese and Physics	Lesson implementation stage-Chinese (*not implemented yet)	Independence stage (*not implemented yet)
Teacher Y					Not involved	
Teacher S						

Table 3: SRF implementation chart for W Secondary School (students and teachers)

Although we are in the midst of our research in these secondary schools, some preliminary results can be reported here. Firstly, the varied degrees of practical support given by the leaders of these two schools towards teachers involved have resulted in varied outcomes. In W secondary school, Teacher S did not continue in the collaboration because there was no substantive offloading of his work. Secondly, the enculturation stage plays again an important role in transiting towards proper usage of GS in the class albeit infusing the enculturation objectives into the school curriculum.

## **5. CONCLUSION**

To integrate technology effectively within school curriculum should not be a mere add-on computer tool but really a transformation of school culture. Researchers and educators aiming to increase sustainability and scalability of technology usage in schools should be ready to work together to deal with a host of challenges. In case of GS technology, the SRF and TAPS have provided a systematic model for gradual and seamless infusion of GS technology in the various schools that we collaborated with. The success of the scale-up GS project from M Primary School testifies to the pivotal role that teachers and school leaders played.

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