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Integrating Technology in the Classroom: Favourable Conditions for Teachers' Upward Developmental Trajectories

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Abstract: In this paper, we study developmental trajectories of three teachers as they integrate GroupScribbles (GS) technology in their classroom lessons over the period of about one academic semester. Coherency diagrams are used to capture the complex interplay of a teacher's knowledge (K), goals (G) and beliefs (B) in leveraging technology effectively in the classroom. The degree of coherency between the KGB region and the affordances of the technology provides an indication of the teacher's developmental progression through the initiation, implementation and maturation phases of using technology in the classroom. Our analysis of these three teachers' trajectories suggests that initial high coherency in a teacher's KGB region and having students who have already been enculturated with the technology-enabled pedagogies accelerate upward developmental trajectories in integrating technology in the classroom.

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

1. Introduction

Teachers play a central role in integrating technology in the 21st century classrooms. Many research studies have shown that teachers' beliefs play an important role in leveraging technologies effectively [1,2]. Schoenfeld [3] further extend this paradigm by showing that the beliefs (B), knowledge (K) and goals (G) of the teacher influence every pedagogical decision. In our previous paper [4] we argued that the coherency between teacher's knowledge, goals and beliefs and the affordances of the technology is the main key in leveraging the technology successfully. Using the Coherency diagrams [4] to examine the developmental trajectories of two primary (elementary) school teachers, we postulated that high coherency at the initiation stage and support for teachers are important factors for successful technology integration. In this paper, we investigate the different KGBs for one primary (elementary) and two secondary school teachers as they integrate a technology called GroupScribbles (GS) in their lessons that seek to employ pedagogies based on the concepts of Rapid Collaborative Knowledge Building (RCKB) [5]. By comparing their developmental trajectories vis-à-vis the Coherency diagrams, we obtain more insights into developing teacher's competencies in using technology in the classroom.

2. The Coherency diagram

The complex interplay between teachers' knowledge (K), goals (G) and beliefs (B) can be represented by the "KGB diagram" (Figure 1). The intersection of the all three elements is marked out by the KGB region in the KGB diagram, shown in Figure 1. This region denotes teacher's selection of knowledge that is based on goals which are prioritized by his or her beliefs. In leveraging technology, the teacher must possess knowledge of the affordances of the technology to achieve goals that are set in the classroom. More importantly, teacher's beliefs provide the affective motivation for teacher to utilize the technology. To capture the relation between the affordances of the technology and teacher's KGB region, the Coherency diagram's intersection region (Figure 1) describes the extent to which the technology is leveraged in teaching and hence, serves as an indicator of the teacher's developmental state in technology competency.

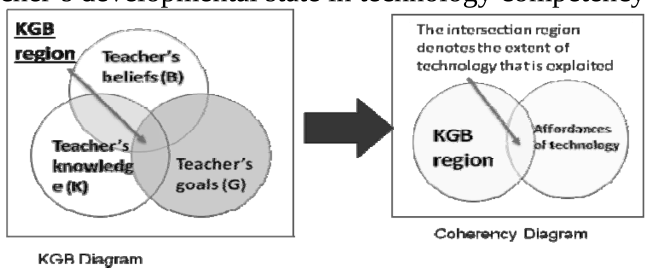


Figure 1: KGB diagram, KGB region and Coherency diagram

In the continuum of intersection regions, we divide into four distinct developmental states (states 1 to 4) to plot the trajectory path of teacher's technology competency across the initiation, implementation and maturation stages of technology implementation. These are reported more in details [4].

(continuum of coherency diagram)

(increasing intersection between KGB region and affordances of technology)

State 1 | State 2 | State 3 | State 4

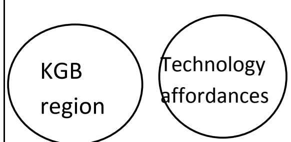
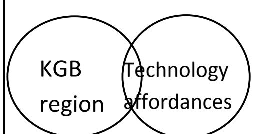
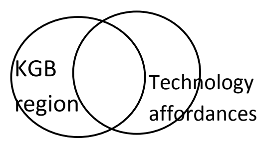
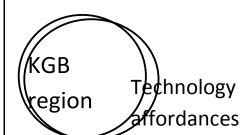
State 1: No coherency	**State 2: Little coherency**	**State 3: Much coherency**	**State 4: Total coherency**
			
There is no intersection. Hence, no coherency at all. Therefore, technology is not leveraged at all.	There is little intersection. Hence, little coherency. Technology is leveraged to a limited extent	There is much intersection. Hence, much coherency. Therefore, technology is leveraged at a large extent	There is total intersection. Hence, total coherency. Therefore, all affordances of the technology are leveraged. This forms the ideal state.

Figure 2: Four states along the continuum in the Coherency diagram

3. GroupScribbles (GS) as a technology that supports RCKB

GroupScribbles (GS) is an interactive technology which enhances the characteristics of sticky paper notes and Student Response System (SRS, sometimes called "clickers"), by providing their key features while avoiding some of their constraints [5]. Developed by Standsford Research Institute (SRI) International, GS enables collaborative generation, collection and aggregation of ideas through a shared space. GS2.0 user interface presents each user with a two-paned window (Figure 3) on a web browser. The lower pane is the user's personal work area, or "private board", with a virtual pad of fresh "scribble pads" on which the user can draw or type. A scribble can be shared by being dragged and dropped on the public board in the upper pane which is synchronized across all devices. 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 [6]. With appropriate class activities, the affordances of GS enable collaboration learning to take place in the classroom.

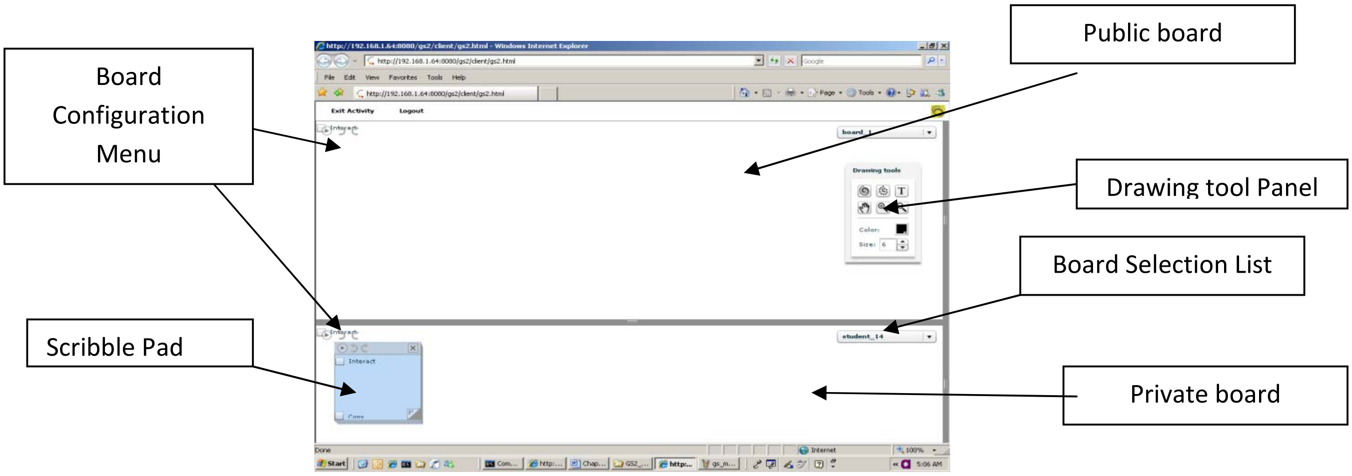


Figure 3: GS 2.0 User Interface

4. Research Context

In our study, we worked with one primary school and two secondary school teachers for about one semester (three to six month). Denise is an experienced primary six (elementary grade 6) science teacher in the latter stages of her successful career in teaching. Previously, she was a Vice-Principal with another primary school before deciding to become a senior teacher in the primary school we are working with. She has about 21 years of extensive teaching in primary schools and is a respected mentor teacher in the school. In contrasts with other teachers in her school, Denise (before our study) is a technology novice, using the computers mainly for grades recording, email communications and word processing. Before our study, Denise commented that she rarely uses technology that supports collaborative learning. Despite this, she was willing to participate in this project. Parry is a young secondary two science teacher of about three years of teaching experience while Jolin is a novice secondary one mathematics teacher of about one year of teaching experience. Being computer science graduates teaching in the same school, Parry and Jolin were designated to collaborate with us in this project by their school. Parry is a sociable and open-minded individual while Jolin is a quiet and passive teacher who desires to complete the syllabus within stipulated curriculum time. Before this study, both teachers have used other ICT tools in their teaching.

In Singapore, the school year starts in January and ends in November. We started working with Denise and Jolin in January 2009 and with Parry in June 2009, in their respective schools. Denise teaches a class of high-ability, GS competent and highly enculturated students who have used GS about one and half year in their lessons. Similarly, Parry teaches a class of high-ability students who have about six months experience with GS. In contrasts, Jolin teaches a class of average ability students who has no experience with GS before our study. Every week for 8 weeks, two lesson periods (totalling an hour and 10 mins) for the respective subjects adopted GS lessons. In these 2 classes of 40 students, each student has an individual Tablet-PC (TPC) with a GS client software installed. We have co-designed, implemented and observed about eight lessons in total.

5. 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 students using GS. Semi-structured interviews were used 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 discussed about the lesson that has been implemented. In the end of semester interview session, the teacher was interviewed by two researchers with a list of prepared interview questions in a private location. The interview session was audio and video recorded.

6. Analysis

This section discusses the use of coherency diagrams in explaining Denise's, Parry's and Jolin's various pivotal decisions to integrate technology into the curriculum. This is done by establishing their beliefs, goals and knowledge in the first instance and employing them as lenses to explain and understand the various GS-related activities in the classroom.

6.1 Parry's developmental trajectory

In the initiation phase, Parry begins his developmental path on a good stead at a high coherency of state 3. There is much alignment between his KGB and his perceptions on the affordances of GS technology evidenced by his perceptions that GS will solve most of the problems he encountered in collaborative group lesson activities he implemented in biology and physics lessons prior to this study. With regards to Parry's beliefs, Parry values every student's contributions and ideas in the class. In his own words, "every student's answers count. I would really like to see their answers in some ways. Students should explore and find things out on their own. In fact, they should take the initiative to learn from one another." Parry also believes that group work is only effective if every student can articulate and "explain their thoughts". In this way, their ideas could be evaluated (by peers or teacher) and thus, learning can take place. However, he laments that "opportunities for expressions are often limited" by time and modes.

Closely linked to his beliefs is his "overarching" goal in integrating GS in his classroom. In the interviews with Parry, he expresses that his main goal is to "maximize learning for students whatever possible." In line with this goal, he commented that "software used in classroom should always help students learn better". In fact, Parry has encouraged students' learning beyond the curriculum content and not on completing the syllabus. Because of his student-centred beliefs, Parry has devised good collaborative lessons that were relevant to the students because Parry perceived that the affordances of GS were congruent with his KGB and thus able to help to solve the problems he encountered in collaborative learning In addition, also believes that a teacher should not appear incompetent before his students. This could be another motivating factor for Parry to pick up the competencies in GS fast and plan his lessons carefully so as not to reveal his inadequacies before a class of GS-enculturated class. Parry started off with a good stead of high coherency state 3.

In the implementation phase, Parry proceeds to implements what he perceived to be coherent in the initiation phase in the classroom. In many of Parry's science lessons, authentic problems in familiar everyday settings are used to formulate open-ended group questions for students to discuss. For example, questions like "explain the similarities and differences of work done and moments using everyday examples", "do you think there is work done in climbing up the stairs?" in lesson 2. By doing this, Parry hopes to trigger the interest level of the students and elicit responses from all students. This stems from his belief that every student should contribute ideas in the class, mentioned in the last section. This belief causes him to leverage on the multimodal affordance of GS which allows students to type, draw or write their answers. This has created more opportunities for students to express their answers in rich diversity, shown in Figure 4 below. Some students prefer to type while some prefer to draw and colour. Some students prefer to verbalise their answers during the lessons. There were active concurrent posting and building on ideas on the shared space on GS within a short period of about 20-30 minutes which would not be possible without GS.

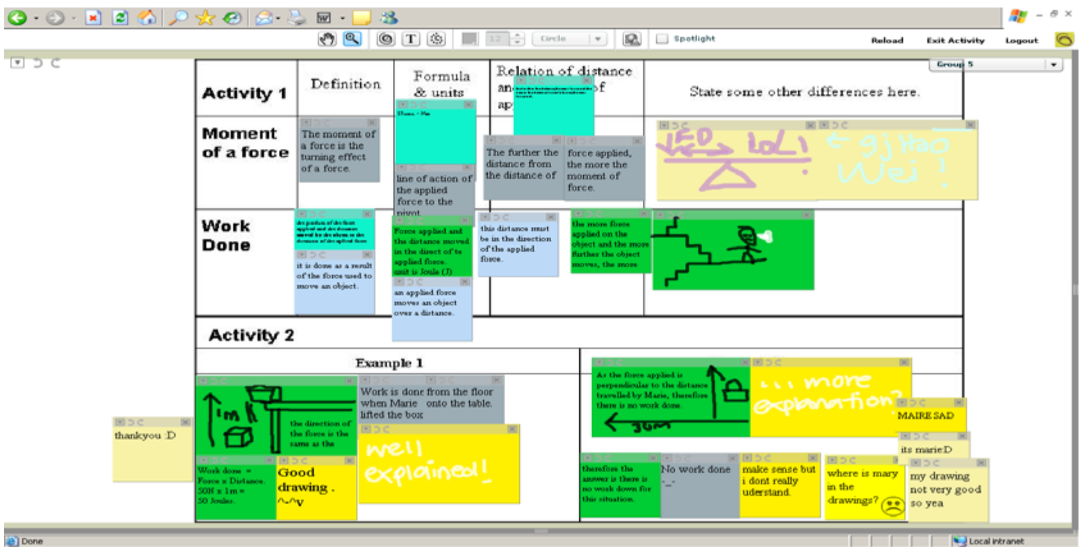


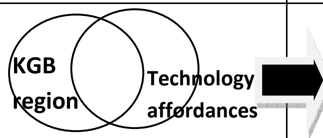
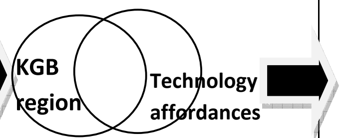
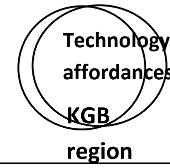
Figure 4: Multimodal expressions in Parry's science lessons

Parry's student-centred belief also enables him to create a collaborative learning environment. In his lessons, students are allowed to express their answers (which may be not in the syllabus) without fear of criticism. In turn, this produces many new and innovative ideas. This is not only seen in verbal articulation but also in written ideas on GS boards. Below is a transcript that happens in the science lesson on force and moments:

> Parry: Any other examples of moments?
> Student 1: Singapore Flyer!
> Parry: Good! Although that is not in our syllabus, it is an interesting example. How does that illustrate moments? (Students in the class begin to see that content outside the syllabus could be discussed in the class, began to raise their hands)
> Student 2: the Ferris wheel turns because of a clockwise moment and an anticlockwise moment with the pivot at the centre.
> Student 3: The engine provides the power to turn at the pivot and there is a change in direction for every passenger every half a revolution. (The discussion continues..)

Beside this, Parry takes time to carefully co-design and rehearse every lesson plans so that he can "appear competent in front of his students". All these points to successful exploiting features of GS in maximizing collaborative learning e.g. viewing other group boards, peer-reviewing each other ideas, posting ideas real time etc because Parry values students' contributions, peer-learning and new ideas. The successful enactment of his congruent perceptions put him in a high coherency state 3.

Table 1: Parry's and Denise's accelerated upward developmental trajectory

	Initiation phase (State 3)	Implementation phase (State 3)	Maturation phase (State 4)
Coherency diagrams			

In the maturation phase, Parry was able to plan innovative lessons that integrate GS without the help of researchers e.g. lesson 6 on heat transfer. Using familiar everyday examples, students were motivated to collaborate with one another via posting and reviewing ideas expressed through different modes in GS, to learn about the various heat transfer mechanisms. In addition, he enjoys GS technology so much that he is exploring the "usage of GS in the laboratory practical lessons" on his own and is tasked by the science department to plan prototype lesson plans for his colleagues to use. Hence, as we trace the coherency diagrams shown in Table 1, Parry exhibits an accelerated upward growth from state 3 to state 4 within a short span of 4 months in implementing technology successfully in the classroom.

6.2 Denise's developmental trajectory

Denise exhibited a similar trajectory as Parry. In the initiation stage, Denise possesses good knowledge of collaborative learning strategies due to her long teaching career. During the pre-intervention interview, she commented that collaborative group work allows students to "think as an individual and as a group." She was able to anticipate some group work problems e.g. "I foresee the possibility of sleeping member in groups so I assign roles". Denise believes in "every student has a different potential that waits to be realised by the teacher". To do that, Denise says that "gaining the students' trust" and building a conducive collaborative environment is important. She "sees every child's strong points and there is a wealth of knowledge where peers can learn from one another". Thus, her goal in the classroom is to maximise every students' potential to the fullest. Beside these, Denise has a high regard for the teaching profession where she believes in "delivering the best lesson possible in order to realise the students' potential". This is manifested in rehearsing her GS lessons several time before the actual implementation so that she can be as, if not more, technically competent as her well GS-enculturated class. She sought to portray herself as a competent teacher, a belief and goal quite similar to Parry. Therefore, Denise's KGB is well congruent with the affordances of GS e.g. shared space platform for posting and building ideas and multimodal expressions. She perceives GS as a tool that actualized her KGB in the classroom and her GS experienced class has provided an added impetus for her to embrace GS positively. That would put her in a good start at a high coherency of state 3.

In the implementation phase, Denise successfully utilizes the shared space in GS fully in a variety of collaborative learning settings e.g. Jigsaw, role-playing, group experiments etc. Similar to Parry, Denise exploits fully the features of GS technology that support collaborative learning e.g. allowing students to peer comment and question each other ideas in real time. At the same time, she also allows her students to express their answers in their desired form-write, type or draw. Coupled with a GS competent class, Denise enactment of her congruent perceptions was successful. This put her in state 3. In the maturation phase, Denise was able to plan GS lessons in another subject i.e. English without any help from the researchers. Survey results have shown that about 92.5% of the students in her class commented that they enjoyed her GS lessons. This indicates Denise attainment of GS competencies in short span of three months. As we traced the coherency diagrams of Denise, there is a similar accelerated upward growth from state 3 to state 4 in implementing technology successfully in the classroom shown in Table 1.

6.3 Jolin's developmental trajectory

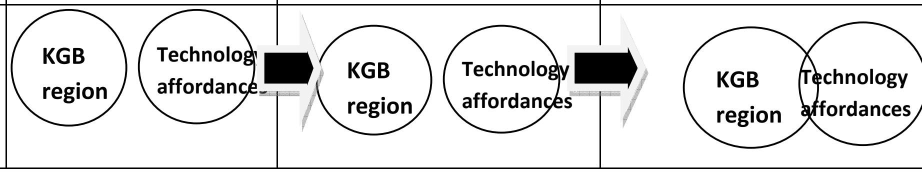
At the initiation stage, Jolin holds several primary beliefs that are incongruent with the affordances of GS technology. First, she expects herself to finish the syllabus on time adhering to a strict schedule called scheme of work (SOW). Secondly, she believes that her students are "not willing to articulate their answers because they are afraid of being identified" and generally believes that "collaborative learning takes up too much time" to wait for students' answers. Coupled with her limited knowledge of collaborative learning strategies, this has caused her to use predominantly didactic teaching strategies approach in teaching Mathematics e.g. enacting IRE (Initiation-Response-Evaluation) episodes frequently in her lessons. Below shows a transcript of a Maths lesson on algebra:

> Jolin: What is the value of b in this equation: "5b+2b=14"? (Initiation)
> Student 1: 2. (Response)
> Jolin: (proceeds to write the answer b=2 on the board without any verbal response) (Evaluation)
> Jolin: What does b mean? (Initiation)
> Student 2: Number of boys. (Response) [Jolin nods her head and continues the lesson.]

Thirdly, she believes in a strict classroom regime where students are expected to be orderly and follows instructions to the minute details in order for effective learning to take place. Therefore, her goals include creating an orderly classroom and complete syllabus on time. The affordances of GS primarily leverage on collaborative discussions and articulation of ideas by students and this requires more time out of the curriculum. Moreover, Jolin faces much difficulty in planning collaborative learning activities for GS-related lessons due to her limited knowledge. All these factors points to the incoherency between Jolin's KGB region and affordances of GS aptly indicated by state 1.

In the implementation phase (part 1), as Jolin enacts the incoherencies perceived in the initiation phase, she is not able to leverage GS technology effectively in her classroom. Firstly, her fear of not completing the lesson on time is realized partly due to her poor time management skills. As students articulates their ideas more in GS group collaboration lessons, Jolin finds it a challenge to maintain an orderly classroom. Jolin wastes a lot of time in trying to enforce discipline in the GS lessons. She expresses her frustration: "I always cannot complete lesson objectives in a GS lessons!". She attributes the poor implementation to misbehaving students in her class and lack of time. Basically, she seems to have stagnated at state 1 at this phase. Realizing her stagnation, we as researchers decided to increase her confidence and motivation by encouraging her to leverage on multimodal affordance of GS technology. Jolin attempts to use this affordance in one of her Mathematics lesson on Number patterns where she experienced some successes. She was surprised herself: "I never knew (GS) works for my students!" One would expect Jolin to grow close to state 3 but apparently not so. In one of recent interview session with her, she commented that "GS is topic dependent and may not be suitable for her class". There are some minor changes in teaching strategies but she remains largely sceptical. Hence, state 2 would describe her current stage. Her trajectory is plotted in Table 2.

Table 2: Jolin's developmental trajectory

	Initiation phase (State 1)	Implementation phase-part 1 (State 1)	Implementation phase-part 2 (State 2)
Coherency diagrams			

7. Discussion and Conclusion

From Tables 1 and 2, we can make some notable assertions. Firstly, this study reaffirms what we observed in our previous study [4]. Teacher's initial state plays an important role in attaining positive growth. Denise and Parry started with state 3 and ended with state 4 at the maturation stage within short span of three to four months. In contrasts, Jolin exhibited little growth from state 1 to state 2 without entering into maturation phase within a longer span of six months. This is because modifying existing beliefs is easier than replacing existing new ones. Time and support from researchers are of secondary importance as compared to teachers' initial KGB coherency. Secondly, a class of highly motivated and competent students provide an added motivation to teachers for positive development at an accelerated rate. Despite starting with good coherency, Lynn, in our previous study [4] took one and a half year as compared to three months for Denise to attain state 4.

In this study, we showed that the coherency diagrams provided insights into teachers' developmental growth in integrating GS technology. Our results reaffirm the importance of ensuring high coherency right at the initiation stage. A class of highly GS-competent and motivated students accelerates the upward development trajectories in integrating GS technology in the classroom.

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