PEDAGOGICAL ACTIONS OF MATHEMATICS TEACHERS VALUED BY SINGAPORE STUDENTS

Berinderjeet Kaur

National Institute of Education

Nanyang Technological University

Singapore

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Abstract

In Singapore, three grade eight classes from three schools participated in the LPS. As part of the study 59 students were interviewed during the post lesson video stimulated interview. Drawing on the interview data of students, in particular responses to two of the prompts used for the interviews:

i) What has to happen for you to feel that a lesson was a "good" lesson?

ii) What are the important things you should learn in a mathematics lesson?

this paper provides insight into students' perspectives of pedagogical actions that facilitate the learning of mathematics. The paper also juxtaposes students' perspectives against the instructional actions of the teachers and explores pedagogical actions of mathematics teachers valued by their students.

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Introduction

The performance in mathematics of eighth graders from Singapore in the Trends in International Mathematics and Science Studies (TIMSS) of 1995, 1999, 2003 and 2007 have been outstanding.(Kaur, 2009a; Mullis, Martin & Foy, 2008). As what students learn is fundamentally connected with how they learn, there is much interest in the teaching and learning of mathematics in Singapore classrooms. However, there is not much research that has been reported on the pedagogy of mathematics classrooms where both teacher and student perspectives have been juxtaposed using data from lessons that have researched students and teachers simultaneously. Several studies, namely Kaur (1997), Kaur and Yap (1998) and Kaur, Koay, Yusof, Taha and Wong (1999), done in the past have documented student expectations of their "best" mathematics teacher using a paper and pencil survey methodology. In these studies students based their responses on experiences. In Kaur (1997) and Kaur and Yap (1998) a group of 2276 Year 9 students were asked, as part of a survey, to list good qualities of the best mathematics teacher they have had. The qualitative data collected were coded and analyzed. The frequencies of the qualities were tabulated. Ranking of the qualities was carried out and a lowest rank corresponded to the largest frequency, i.e., the quality with the largest frequency was ranked first, second largest frequency was ranked second, etc. The top seven qualities ranked by the students were patient, understanding, caring / kind, ***good in mathematics***, ***explains clearly, ensures students understand***, and **provides *individual help***. Of the top seven qualities ranked by the students four were related to teachers' pedagogical actions.

Kaur, Koay, Yusof, Taha and Wong (1999) used the same instrument as Kaur (1997) and collected data from 334 Year 6 students in Singapore and Brunei. They coded the data and analyzed it under four categories: personal qualities, instruction/pedagogy, relationship/rapport and homework policies/expectations. Once again, frequencies were tabulated and ranking of qualities was carried out. Only the findings for the Year 6 students in Singapore are reported here. Among the top three qualities in the respective categories related to teachers' pedagogy were ***explains clearly, ensures student understand*** and ***goes through homework*** and ***does constant review of concepts and skills.***

In another study, Kaur (2004) documented the expectations of mathematics teachers about desired qualities of a good mathematics teacher, again using a paper and pencil survey methodology. This was a small scale study. Data were collected from 38 secondary school mathematics teachers and seven heads of mathematics departments in secondary schools. The responses were coded and analyzed according to the following five categories: personal qualities, rapport/relationship with students, teaching qualities, expectations of student work and 'others'. Once again, frequencies were tabulated and ranking of responses was carried. Among the top five qualities for each category related to teachers' pedagogy were ***good in mathematics, have a sound knowledge of how pupils learn, able to arouse and sustain interest, engage pupils through a repertoire of teaching strategies and provide timely and purposeful feedback to pupils and their parents; expectations of student work – neat and clear presentations, should be original and not copied from peers, work to be submitted on time, corrections must be done when necessary,*** and ***math file or book must be orderly and tidy.***

In the UK, Hoyles et al. (1984), in their study of pupil perspective in the Mathematics Teaching Project interviewed pupils individually to obtain a description of classroom events chosen by the pupils as practical manifestations of one or more of the positive characteristics

which they had attributed to their teacher. The interview data showed that their responses were rarely random or illogical. They were based on quite rational and consistent abstractions of their learning experiences. During the interview, pupils never explored the structure and composition of the mathematics taught. The findings of all the above five studies, Kaur (1997), Kaur and Yap (1998), Kaur, Koay, Yusof, Taha and Wong (1999), Kaur (2004) and Hoyles et al. (1984) showed that students attach importance to practices and behaviours concerning their teachers, when learning mathematics. The above five studies also show that several attempts have been made in the past to seek students' and teachers' perspectives on what is important regarding the teaching and learning of mathematics. However the above studies do not provide us with insights to the pedagogical actions of teachers that are valued by students as statements such as "ensures that pupils understand" resulting from paper and pencil survey data are subject to the readers interpretation that may not be an accurate representation of the subject's intention (see Kaur (2008) for in depth discussion of interpretations of "qualities" arising from the above five studies).

The Learner's Perspective Study (LPS) (Clarke, Keitel & Shimizu, 2006), motivated by a strong belief that the characterization of the practices of mathematics classrooms must attend to learner practice with at least the same priority as that accorded to teacher practice has attempted to capture both teacher and students actions simultaneously with the intent to negotiate meanings in mathematics classrooms. In Singapore, three grade eight classes from three schools participated in the LPS. As part of the study 59 students were interviewed during the post lesson video stimulated interview. Drawing on the interview data of students, in particular responses to two of the prompts used for the interviews:

i) What has to happen for you to feel that a lesson was a "good" lesson?

ii) What are the important things you should learn in a mathematics lesson?

this paper provides insights into students' perspectives of pedagogical actions that facilitate the learning of mathematics. The paper also juxtaposes students' perspectives against the instructional actions of the teachers and explores pedagogical actions of mathematics teachers valued by their students.

The LPS Study in Singapore

The study in Singapore adopted the research design as set out in the LPS (Clarke, 2006). The LPS adopts a complementary accounts methodology (Clarke, 2001) to negotiate meanings in classrooms. The complementary accounts methodology developed by Clarke and used in a large scale study reported in Clarke (2001) enables researchers to record the interpersonal conversations between focus students during the lesson and identify the intentions and interpretations of participants' statements and actions during the lesson through video simulated interviews. The LPS adopted the complementary accounts methodology to document sequences of lessons, ideally of an entire mathematical topic. In Singapore video-records of 13 consecutive lessons (three during the familiarization stage and ten as part of the study) for each teacher were collected using three cameras, the Teacher camera, Student camera focused on a group of two students, known as the "focus group" and captured their actions and talk during the lesson (each group of students was only videotaped once) and the Whole Class camera captured the whole class in action. A split-screen video record mixed on-site from the Teacher and Student camera images was used as a stimulus for students to reconstruct accounts of classroom events during the interviews. Two students from the focus group were interviewed separately after each lesson. Student artefacts (e.g. worksheet and homework) from the focus group were also collected after each lesson. The teachers were interviewed three times, once each week. The interviews were based on a lesson the teacher had taught during the week and the video recording of the lesson was used as a stimulus for the teacher interview. In addition to the teacher interviews, the teacher completed two

substantial questionnaires before and after video-taping as well as a shorter questionnaire after each videotaped lesson.

In Singapore, three mathematics teachers recognized for their locally-defined 'teaching competence' participated in the study. These teachers were recognized for their teaching competency in their respective schools. As part of the study both student data and teacher data were collected from three "well taught" classrooms. The teachers were teaching Secondary Two Express (Grade 8) classes with class size of 37, 40 and 40 respectively. For the specific purpose of this paper, only the necessary prompts used by the interviewer for the student interviews are given. They are as follows:

* Please tell me what you think that lesson was about?
* How, do you think, you best learn something like that?
* What were your personal goals for that lesson?

{*Here is the remote control for the video player. Do you understand how it works?*}

* I would like you to comment on the videotape.

  You do not need to comment on all of the lesson.

  Fast forward the videotape until you find sections of the lesson ***that you think were important***.

  Play these sections at normal speed and describe for me what you were doing, thinking and feeling during each of these videotape sequences.

  You can comment while the videotape is playing, but pause the tape if there is something that you want to talk about in detail.

* After watching the videotape, is there anything you would like to add to your description of what the lesson was about?
* What did you learn during the lesson?
* Would you describe that lesson as a good one for you?

* What has to happen for you to feel that a lesson was a “good” lesson?
* What are the important things you should learn in a mathematics lesson?
* How would you generally assess your own achievement in mathematics? etc..

Analysis of Data and Findings

In school 1 (SG1), school 2 (SG2) and school 3 (SG3) the number of students interviewed were 19, 20 and 20 respectively. All the interviews were transcribed and for the purpose of this paper, the qualitative response to the following two prompts:

i) What has to happen for you to feel that a lesson was a “good” lesson?
ii) What are the important things you should learn in a mathematics lesson?

constitute the data. The frameworks used to analyse the qualitative data are derived using the grounded theory approach (Glaser and Strauss, 1967).

What has to happen for you to feel that a lesson was a “good” lesson?

For the analysis of the responses to the prompt “What has to happen for you to feel that a lesson was a “good” lesson?”, a framework that emerged from an earlier analysis of lesson segments that student’s attached importance to during their lessons was used to analyse the qualitative responses. The development of the framework has been reported in detail elsewhere (Kaur, 2008). The framework comprises of three main aspects of the teachers instructional practice, namely exposition or whole class demonstration, seatwork and review and feedback. Exposition was characterized by whole class mathematics instruction that aimed to develop students’ understanding of mathematical concepts and skills; seatwork was characterized by the period during which students were assigned questions to work on either individually or in group at their desk and review and feedback was characterized by the review of knowledge and work done by students. Each aspect had several sub-categories. Table 1, shows the sub-categories.

Table 1: Sub-categories of the three main aspects of the instructional practice

Exposition (Whole class demonstration)	**EC** – teacher explains / explains clearly **D** - teacher demonstrates a procedure, "teaches the method" or shows using manipulative a concept / relationship **NK** - teacher introduces new knowledge **GI** - teacher gives instructions (assigning homework / how work should be done / when work should be handed in for grading, etc.) **RE** - teacher uses real-life examples during instruction
Seatwork	**IW** - students working individually on tasks assigned by teacher or making / copying notes **GW** - students working in groups **M** - material used as part of instruction (worksheet or any other print resource)
Review and Feedback	**PK** - teacher reviews prior knowledge **SP** - teacher uses student's presentation or work to give feedback for in class work or homework **IF** - teacher giving feedback to individuals during lesson **GA** - teacher giving feedback to students through grading of their written assignments

A review of the transcripts showed that responses may be analysed for two main aspects, the instructional practice of the teachers and other factors that account for learner's engagement.

For the purpose of this paper, only the analysis for the instructional practice of the teachers will be the focus. Table 2, shows the analysis of three students' responses.

Table 2: Analysis of students' responses

Student ID	Response	Inferences drawn about	
		Instructional Practice of Teacher	Learner's Engagement
SG 1-4	Mm there's explanation[1]. There's practice[2]. The teacher showed you the comparison between the wrong method and the correct method[3]. The teacher correcting you[4]…like when you're lost then maybe she's there to help you as a class or personally.	1 - teacher explains (EC) 2 – seatwork (IW/GW) 3 – teacher reviews student work and gives feedback (SP) 4 – teacher shows students the method (D)	
SG 2-7	The teacher will recall back some of the things she teach us on at the previous lessons yeah and and show it to us and let us recall back[1]. Then later she will teach us new methods[2].	1 – teacher reviews prior knowledge (PK) 2 – teacher introduces new knowledge (NK)	

SG 3-7	Teacher to explain[1] those important points which most student does not understand it[2]. Then give more test so that student will remember the steps, most of the time[3]. Tell us jokes ah give us some break or may be show some funny videos lor[4]. To make us more alert instead of just talking then this will make us very tired.	1 – teacher explains (EC) 2 – teacher gives feedback and reviews knowledge (SP) 3 – constant review / practice use of knowledge via assessment	4 – need some non-mathematical fillers (jokes, video-clips) to remain engaged during the lesson

Analysis of the 59 responses revealed that students felt that their lesson was a good one when their teachers enacted one or more of the following pedagogical actions. Teacher

- explained clearly the concepts and steps of procedures,
- made complex knowledge easily assimilated through demonstrations, use of manipulatives, real life examples
- reviewed past knowledge
- introduced new knowledge
- used student work/group presentations to give feedback to individuals or the whole class
- gave clear instructions, related to mathematical activities for in class and after class work
- provided interesting activities for students to work on individually or in small groups
- provided sufficient practice tasks for preparation towards examinations

What are the important things you should learn in a mathematics lesson?

The responses to the prompt "What are the important things that you should learn in a mathematics lesson? were collected from the transcripts. Table 3 shows examples of responses.

Table 3: Examples of responses to the prompt: What are the important things that you should learn in a mathematics lesson?

Student	Response
SG 1 - 11	The concepts and the methods or the rules to solve certain questions.
SG 2 - 1	Understanding maths. Er ... actually I learn more than maths. Cooperating with friends all these and communicating. When we grow up , if we go out and work we still have to do there's project. Then we need to be like ... we must know how to ... communicate with people and yeah.
SG 3 - 13	I like the feeling, really. When I find out the answer of one question. Because I like to take challenge on myself.
SG 3 - 16	Formulas, formulas like the Pythagoras theorem, the sine, cosine ... And just like, to me I think is to win people. Get you know [laughs] because last time in primary school I not so good, until this time when first time when I got first, I was like overjoyed until cannot sleep. So ... okay ah so I try to get first for the whole year ah then managed ah but now because of the new guy not first already ah [laughs].
SG 3 - 20	Er ... what are the methods in solving the questions. Er ...the understanding of a question. Er ... because because er some of the questions are rather confusing ah. What and must know to what we are trying to find.

From Table 3, it is apparent that the response of student SG3-13 and part of the response of student SG3-16 were not directly related to the prompt posed. Excluding these responses, the rest were first scanned through for common themes, following which the responses were analysed based on the emerging themes. The process was iterative and inevitably "a progressive process of sorting and defining and defining and sorting" (Glesne, 1999, p. 135) led to the following categories:

- Habit of mind
- Social skills
- Regulation of learning
- Acquisition of knowledge

that guided the analysis of the responses.

A second layer of analysis led to various sub categories. Table 4 shows examples of student responses that were classified according to the various categories and sub categories that arose from the researcher's interpretation.

Table 4: Categories and student responses

Category	Student responses
Habit of mind [HM]	
Be open and flexible (OF)	SG1-01: Try not to confuse yourself. And then just tell yourself there are... ways to find the answer ... try not to stick to one method. SG1-16; when you get it wrong you should actually er // think of ways to get it.
Check your work (CW)	SG2-10: Mm... not be careless when you finish your – must check if anything is wrong when you finish your equation or problem sum...

Social skills [SS]	
Learn to cooperate Learn to communicate	SG2-01: Er... actually I learn more than maths. Cooperating with friends and all these and communicating. When we grow up, if we go out and work we still have to do there's project. Then we need to be like...we must know how to... communicate with people and yeah.
Regulation of learning [RL]	
Understand the lesson (UL)	SG1-04: understanding the lesson.
Learn from mistakes / knowledge of errors and causes (LM)	SG2-14: Mm ... understand er mistakes your mistakes um ... and actually er not only your mistakes but common mistakes made.
Apply knowledge (during test / examination) (AK)	SG2-11: Er ... how to apply what she told you in...// whatever the worksheets she gives you. How... basically... whether if you take a test on this you're going to do well or not.
Develop procedural fluency	SG2-17: You just have to understand the formula and and it's not about memorizing it's that it's about doing lots of practices and then from there, er with practices you get ...
Build a sound foundation of knowledge	SG2-09: I think like er... to ... know the basics ah. The basics are like the er... the algebra right the first lesson she already taught us that ... like er A plus B right then the whole thing bracket square right is not equal to A

Acquire an extensive range of problem-solution types linked to concept taught	square plus B square. That one is for almost in all the lesson we must use it ah. SG2-04: The different types of sums that this concept can be tested on. Like because a formula can – a concept can be tested on different things. Er ... the way it is being tested is different and we must be exposed to the different type of ways that they test us. So as to ... get well ... to understand maths better and ... able to use maths later on in life. Ah I think so.
Acquisition of knowledge [AK] New knowledge Conceptual knowledge Procedural knowledge (Skills) Knowledge of formulae / algorithms / generalisations	 SG1-05: Learn new things. SG1-07: All the how to solve these types of questions loh. Is like yeah // understand the understand the concept. SG2-03: The important ways to... the steps to take to... to... do the question SG1-12: The important maths formula, formula.

Analysis of the relevant responses revealed that some of the important things that students felt that they should learn in a mathematics lesson were aspects of:

1. Habit of mind
    a) Be open and flexible – explore different approaches to solve mathematical tasks, particularly when you use a specific approach and get an incorrect solution, you must

be open and flexible to explore other approaches as surely there is a way to the right answer.

b) Check your work – to rule out careless mistakes.

2. Social skills

a) Learn to cooperate – during math lessons when working in groups it is important to learn how to cooperate.

b) Learn to communicate – during math lessons when working in groups, it is important that students also get opportunities to communicate with each other.

3. Regulation of learning

a) Understand the lesson – this was a very general statement and what led to understanding was not elaborated. Therefore it is not possible to make any inferences beyond the general statement.

b) Learn from mistakes / knowledge of errors and causes – it is important to acquire knowledge of what may go wrong and why it may go wrong.

c) Apply knowledge (during test / examination) – it appears that it is important to learn how to apply the knowledge taught as performance in math tests / examinations is dependent on it.

d) Develop procedural fluency - it is important to have lots of practice as it would lead to understanding of the formula and use of it.

e) Build a sound foundation of knowledge – it is important to have a sound foundation of the basic concepts of a topic taught as they impact subsequent development of the content of the topic.

f) Acquire an extensive range of problem-solution types linked to concept taught – it is important to acquire knowledge of a wide range of possible questions and their

respective solutions related to a topic so that one may draw on this knowledge when confronted with similar tasks during tests or examinations.

4. Acquisition of knowledge

a) New knowledge – it is important to learn new knowledge, "*learn new things*".

b) Conceptual knowledge – it is important to "*understand the concept*".

c) Procedural knowledge – it is important to learn "*the steps to take to... to ... do the question*".

d) Knowledge of formulae / algorithms / generalisations – it is important to learn "*the important maths formula, formula*".

Discussion

Table 5, summarizes the findings of the data presented and analyzed in the paper arising from the two prompts: "What has to happen for you to feel that a lesson was a good one?" and "What are the important things that you should learn in a mathematics lesson?"

Table 5: Summary of data

What **has to happen** for **you to feel** that **a lesson was a good lesson**?	What are the **important things** that you **should learn in a mathematics lesson**?
<u>Pedagogical actions of teachers</u> - explained clearly the concepts and steps of procedures, - made complex knowledge easily assimilated through demonstrations, use of manipulatives, real life examples - reviewed past knowledge - introduced new knowledge - used student work/group presentations to give feedback to individuals or the whole class	<u>Important things to learn</u> Habit of mind - be open and flexible - check your work Social skills - learn to cooperate - learn to communicate Regulation of learning - understand the lesson - learn from mistakes / knowledge of errors and causes - apply knowledge (during test / examination)

- gave clear instructions, related to mathematical activities for in class and after class work - provided interesting activities for students to work on individually or in small groups - provided sufficient practice tasks for preparation towards examinations	- develop procedural fluency - build a sound foundation of knowledge - acquire an extensive range of problem-solution types linked to concept taught Acquisition of knowledge - new knowledge - conceptual knowledge - procedural knowledge - knowledge of formulae / algorithms / generalizations

In Kaur (2009b), which is also based on the LPS data from Singapore, it was found that the characteristics features of the instructional approaches of the three teachers, in another words the lessons of the students from the three schools had the following similarities:

i) The very specific instructional objectives that guided each instructional cycle, with subsequent cycles building on the knowledge;

ii) The carefully selected examples that systematically varied in complexity from low to high used during whole class demonstration;

iii) The active monitoring of student's understanding during seatwork, as teachers moved from desk to desk guiding those with difficulties and selecting appropriate student work for subsequent whole class review and discussion; and

iv) Reinforcement of student understanding of knowledge expounded during whole class demonstration by detailed review of student in class work or homework.

Juxtaposing the characteristic features of the instructional approaches of the teachers and the findings of "What has to happen for you to feel that a lesson was a good lesson?" and "What are the important things that you should learn in a mathematics lesson?" it is found that only one aspect of the teachers' instructional practice found in Kaur (2009b), i.e. ***reinforcement of student understanding of knowledge expounded during whole class demonstration by detailed review of student in class work or homework*** was common to all three sets of

findings. This shows that when we studied the teachers' instructional practices by analysing their lesson structures and the mathematical tasks they used we were not able to study the impact of their actions on the students learning. As 94%, 85% and 84%, (reported in Kaur (2009b)), of the students from Schools 1, 2 and 3 respectively felt that their teacher's lesson was a good one for them it may be inferred that the findings related to desired pedagogical actions resulting from the prompt "What has to happen for you to feel that a lesson was a good one?" may be considered as pedagogical actions of mathematics teachers valued by their students. Therefore, the following:

- explained clearly the concepts and steps of procedures,
- made complex knowledge easily assimilated through demonstrations, use of manipulatives, real life examples
- reviewed past knowledge
- introduced new knowledge
- used student work/group presentations to give feedback to individuals or the whole class
- gave clear instructions, related to mathematical activities for in class and after class work
- provided interesting activities for students to work on individually or in small groups
- provided sufficient practice tasks for preparation towards examinations

were commonly found in the mathematics lessons of the students that participated in the LPS study. The findings of the responses to the prompt "What are the important things that you should learn in a mathematics lesson?" have added a very significant dimension to the findings about the pedagogical practices of the teachers. Other than ways and means of regulating their learning (see table 5 for details) and acquisition of knowledge (see table 5 for details) implicit to the actions of the teachers, students have reported the development of aspects of ***habit of mind***, such as be ***open and flexible***, ***check your work*** and ***social skills***, such as ***learn to cooperate*** and ***learn to communicate***.

Conclusions

With limitation and based only on the happenings in the classrooms of three grade eight competent mathematics teachers and their students perceptions of their lessons it may be said that ***pedagogical actions of mathematics teachers valued by Singapore students*** which facilitated their learning of mathematics were linked to regulation of learning and acquisition of knowledge from the students' perspectives. To facilitate students ***understanding of the lesson***, teachers ***explained clearly the concepts and steps of procedures***, ***made complex knowledge easily assimilated through demonstrations, use of manipulatives and real life examples.*** To enable students to l***earn from mistakes and acquire knowledge of errors and their causes***, ***build a sound foundation of knowledge***, teachers used s***tudent work or group presentations to give feedback to individuals or the whole class*** highlighting the errors and possible causes thereby enabling students to clarify their understanding of the mathematics taught further. To enable students ***to apply knowledge during tests and examinations***, ***develop procedural fluency***, teachers ***provided sufficient practice tasks for preparation towards examinations***. To help students acquire ***new knowledge, conceptual knowledge, procedural knowledge and knowledge of formulae / algorithms / generalisations*** teachers ***reviewed past knowledge*** and ***introduced new knowledge***.

Pedagogical practices of the teachers, such as ***provision of interesting activities for students to work in small groups*** nurtured the development of students' social skills such as ***learning how to cooperate*** and ***learning how to communicate***. Last but not least, it may be inferred that ***students valued whatever the teacher did*** to ***nurture habits of mind*** such as ***being open and flexible*** and ***checking their work for correctness and careless mistakes***.

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