The Role of Primary Science Teachers' Subject Matter Knowledge & Pedagogical Content Knowledge in Lesson Study

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"The challenge is to get inside the heads of practitioners, to see the world as they see it, then to understand the manner in which experts construct their problem spaces, their definitions of the situation, thus permitting them to act as they do" – Lee S. Shulman in The Wisdom For Practice.

Abstract

Four primary science teachers worked as a lesson study team to develop a grade six science lesson on the topic, "Negative Impact of Humans on the Environment". The lesson involved a science experiment to help students understand how the removal of vegetation cover through human actions impacts soil erosion leading to landslides. The lesson study processes of planning, enactment of a research lesson and post research discussion were audio-taped as well as videoed. This paper will present the analysis of discourse patterns among teacher participants and explores the role of primary science teachers' subject matter knowledge (SMK) and pedagogical content knowledge (PCK) in crafting, implementing and revising a research lesson as part of the lesson study process and how Lesson Study improves them.

Introduction

Lesson Study is a powerful tool for the professional development of teachers in Singapore - a process of developing communities of practice among teachers with support from teacher educators. Teachers are necessarily at the center of any curriculum improvement initiatives in which Teach Less Learn More (TLLM) is one. High standards and greater engagement in the classroom are largely dependent on the quality of teaching and learning in the classroom. It is important, therefore, to have a focus on teacher professional development in any systemic reform initiatives as many teachers may not be prepared to implement new teaching practices where a relatively high standard of understanding is needed**.** High-stakes national examinations in the Singapore educational system puts pressure on many teachers to adopt more traditional pedagogies that focuses heavily on memorizing facts, where acquiring deeper understanding of the subject knowledge taught would be a welcomed luxury that they feel is not achievable due to time constraints.

Many teachers lack theoretical underpinnings of alternative ways of teaching nor have the tools or skills to undertake research of their own practice. This prevents teachers from enhancing the quality of teaching that can impact student learning in their classrooms. . Though curriculum slippages does and will occur for many reasons, a major contributor would often be due to the consequences of classroom practitioners "continuing to treat curriculum theory and practice as separate domains" (Buxton & Lee, 2007, p. 42). The presence and direct support of teacher educators in LS cycles becomes an even more powerful tool for the professional development of teachers whose distance between curriculum theory and practice is furthest away. The involvement of teacher educators in LS cycles allows more inputs and insights into how subjects can be taught, and how students learn these subjects. It was with this understanding that a group of science teachers in Cedar Primary were provided with a platform to be immersed in the issues of teaching the teaching of Science.

But while the rhetoric is that LS is a site of teacher collegiality, boundary encounter (Cobbs et al., 2003) with teacher educators and subject matter experts, and therefore increased teacher learning, how true this is requires more attention. Little systematic research has been conducted in Singapore on the effects of LS as a professional development on improvements in the teaching of Science. There is therefore a clear need for research on the effectiveness of LS for the professional development of teachers and the issues of such implementation. This paper looks into how LS can be used to identify weaknesses in teachers' Pedagogical Content Knowledge (PCK) and Subject Matter Knowledge (SMK) in the teaching of primary school Science. It also discusses briefly into the issues of boundary encounters between classroom practitioners and teacher educators.

Context

Cedar Primary School is a relatively small school situated in Cedar Avenue. It embarked on its very first Science Lesson Study in 2007. For this cycle, all four Primary 6 teachers in the school were involved. Three out of four of these teachers were teaching Primary 6 Science for the first time and were thus only vaguely familiar with the syllabus.

Teacher	Years In Service (on 1/1/2007)	Official Post	Times teaching P6 Science before the cycle
T1	2.5	Science Coordinator	0
T2	7	Classroom Teacher	0
T3	6.5	Head of Department, Language Arts	4
T4	1.5	Classroom Teacher	0

They were joined by a Lesson Study facilitator (LSF) and a science subject matter expert (SME) from the National Institute of Education (NIE) and a research assistant (RA). Though the school has had Lesson Study since early 2006, and all four Primary 6 teachers have therefore been involved in at least one previous cycle of Lesson Study, this would be the first time a Science Lesson Study is being conducted. The study took place intensively between February and April of 2007. The team met weekly and all deliberations are observed by CRPP's RA and are recorded either in audio, on video, or both and are used as data for this paper. Data recorded in audio format has been transcribed for analysis purposes

Role of PCK and SMK

Shulman (1986; 1987) argued that a teacher's pedagogical content knowledge (PCK) exists and is built upon the teacher's subject matter knowledge (SMK). According to him, PCK guides a teacher's actions in a classroom by guiding him/her how to structure and represent academic content for direct teaching to students. A teacher's PCK 'includes an understanding of what makes the learning of specific topics easy or difficult' and more importantly, it also includes the awareness of the teacher that the students bring their own conceptions and preconceptions into the class and that these preconceptions could also likely be misconceptions (Shulman, 1986, pp 9 – 10). PCK and SMK thus allow the practitioner to address students' learning needs in any particular classroom circumstances.

SMK also has a role in the choice of topic teachers choose for them to do their LS cycle. Since most of the teachers were first timers in the level, the team had difficulties identifying a lesson that students generally had difficulty in understanding. This prompted them to seek the opinion of the teachers who had more experience teaching the upper level. Of the list of topics given in which students had difficulty in, the topic on the negative human impact on the environment was agreed upon and more specifically the lesson on soil erosion. The topic was also of interest to the other teachers because only a few weeks before the deliberations there were real landslides that occurred in Singapore's Hillview Residence of Jalan Dermawan that became news in the local daily (ST, 19/12/2006). Teachers found this a good opportunity to bring real life events into the classroom and use such teach-able moments in the teaching of Science. This last fact was also agreeable to the pedagogical preference of the other group members who were also mainly English Language teachers. Bringing in newspaper cuttings into the classroom to teach language is done quite frequently in classrooms by language teachers who believe in the advantages of using real-life examples in their classroom teaching.

This pedagogical belief in making lessons as authentic as possible to real life also resulted in the initial decision to make persuasive writing as the main task of the research

lesson activity. The teachers believed that Cedar students have been sufficiently exposed to local green issues but their knowledge was fragmented and incoherent. Furthermore, the teachers believed that these students were not able to articulate their understanding persuasively and convincingly due to the fact that they were not used to the ethical use and proper citation of scientific knowledge especially those that they have cited from the internet, the most common source of scientific knowledge quoted whenever students are asked to research on a topic. It is only when the Science SME joined in the deliberations that it was pointed out that technically the lesson that they have been planning was more an English language lesson. The role of authentic pedagogy in Science became very clear in the Post RL1 deliberations.

LSF: I think in our deliberations over the weeks, one of the things we struggled with is this whole notion of authentic pedagogy. And at one point we asked this question, what exactly is authentic pedagogy? What does it really mean and I think we in the sense came to an understanding when we had our discussion with SME, our resource person that really in the teaching of primary science, we really want a pedagogy where our children have the opportunity to think like a scientist, you know and whether or not the pedagogy that we will use within our research lesson would allow children to think like a scientist.

These were initial indicators that the teachers were not familiar with the differing pedagogical elements of different subject matter. For example, before the subject matter expert was involved in the deliberations, the teachers focused on the ability of the students to focus on citing the information they use in their persuasive lesson:

T1: So in the persuasive writing style or genre, I think whatever type, whatever kind of writing, whatever sources that you take must be cited right. So that's one of the criteria here.

T2: So only persuasive writing. Because it's writing, so as long as you get you know some evidence.

Though teaching how to cite sources of information is important in the education of our students, it is not within the Science syllabus but falls under I.T. Education. To make citing of information on the internet as the focus of the Science Lesson Study Research Lesson, is therefore a clear indication of the teachers' lack of understanding of what is

important in a science lesson. As such, Lesson Study managed to surface misconceptions within teachers about the differing subject-specific PCK and the different objectives of each syllabus. There were also indicators that the teachers were not familiar with the subject matter that they are teaching. In the initial planning discussions, the teacher who have had four years of experience teaching science, brought a photograph of coastal erosion, and the discussion centered on that photograph, on whether it should be used as part of the pre-test.

T4: Soil erosion. It wasn't caused by…
LSF: Was it coastal erosion?
T4: No…
T3: Coastal… ya…
LSF: It's coastal erosion…?
T4: Coastal erosion that means it's by the waves.
LSF: By the waves right?
T3: Ya.
LSF: But that is natural factor…

The confusion between what is erosion aggravated by man and natural erosion is the core component of this lesson. LS allowed the teachers to interact with the SME and LSF and each other, promoting teacher collegiality so as to enable them to eradicate their own misconceptions about the subject matter. This constant contact and deliberation between teachers also allow them to see possibilities in their lessons that they might have otherwise not see. What could be perceived as difficult to prepare could actually be something that is easily done. An example below demonstrates this:

T2: To be controlled, if to be exactly one point two five, everybody also must be exactly one point two five, not much not less. I think that's what she's trying to say here lah. Which I think is quite valid lah, but uh to have uh (…) to have that type of experiment, I think for primary level may be a little bit difficult?
T3: But you can give it a try.
SME: I don't think it's difficult you know.
T2: That means we have a lot of close control, a lot of variables to be seen ah.
T1: Okay unless we design all right…
SME: Yah but the basis of scientific investigation is everything has to be controlled except your start, the variable that you're studying, otherwise uh, you know…

The inexperience of the teachers in preparing for this unit of the science inquiry lesson made the teachers unaware of how easy the preparation for this experiment could be. The importance for its preparation in science inquiry lessons were again realized and enforced during the research lesson. The transcript during the post research lesson conference communicates this:

T1: **Secondly, I think one period might be a little bit too short for this because there are some things that we need to reinforce. I think the students would be able to learn more if they are able to explore more. We should have prepared.**

SME: **I think you are probably right. We should have more time especially the experiment because that would allow the students to explore it more. In this case it was already set for them, if they really want an exploration, we should be given time to set it up and explore on their own…**

LSF: **Erm… ok! I guess when the comment is raised in any kind of experiment we do with the children, the preparation is very important so that it is easier to manage the experiment…**

This preparation needed includes the necessity for teachers to test the experiment that they have designed to see if it would happen as predicted.

LSF: **Just out of curiosity, when the kids were doing the experiment and held the hair net and stocking they poured the water and they observed the water is coming out, what was your thought that came through your mind? Did it come out as predicted?**

T4: **No**

LSF: **Why, why was that?**

T4: **I think for only one setup it was a bit clear but for the rest it wasn't very clearly visible.**

T2: **We predicted that when we looked a the hair net and the stockings, I thought the stocking would be slightly better. But when it came out the same, I was quite surprised. In my mind I was thinking how I am able to explain to the pupils if I were to conduct the lesson. I think the one on the slope was clearer. The slope's much clearer.**

LSF: **When you look at it, the first reaction was, 'Oh it is not working!' So that was first thought until I look at it more carefully and I saw that there was clearer water because there were bigger sediments and actually I whispered to T1 to remove the bottle to see the amount of sediment beneath the bottle in the setup that used the net**

T1: So visually the kid is immediately caught, so by knowing this, we would be able to correct misconceptions

As shown above, the research lesson also allowed many observers to take note of many different things at once. This is important so that important details of the lesson were not missed. The lesson also surfaced other issues concerning classroom pedagogy employed. In the first research lesson, the lack of proper directions in employing group work was very apparent

LSF: I can't remember whether or not you gave the kids certain roles to play. Did they allocate amongst themselves what they were supposed to do or they just decide amongst themselves what they are supposed to do? In teams.

T1: In P4 we actually had them like roles, Number 1 to do this, Number 2 to do this and so on. But when it comes to P5 they were quite automatic. So I admit it was wrong for me for this lesson to assume that automatically for the student. I think because it was quite a new setting for them, the slope. They were not sure as to what to do.

The examples given above are only a sample of many others obtained from the video and audio transcripts. From the above, we could safely conclude that LS is a powerful tool for the professional development of teachers in Singapore by allowing direct access to teachers' PCK and SMK. This allows teacher educators and subject matter experts, direct situative perspectives on how classroom teachers, using their own PCK, understand what they perceive as a problem in students' cognition through their negotiation with other practitioners.

Sources of Resistance

Other than professional development through the formation of a teacher discourse community, LS also highlights how a teacher discourse community can identify major stumbling blocks to pedagogical improvement. In our observations of this cycle of LS, it was very apparent that there was resistance towards the suggestions given by the SME on how to improve the quality of the lesson. This resistance was mainly because of the lack of time. With the approaching Primary School Leaving Examinations (PSLE), a high stakes

examination, at the end of Primary 6, it is obvious that was always a sense of urgency to complete the LS cycle so that they can finish completing their P6 Syllabus. As the examples below demonstrates:

T4: Okay? So as we were discussing we will… revise the pre-test.
T1: Fill up diagram, show a video. We have decided, due to the lack of time. Due to the lack of time, we have decided to concentrate on the… cause and effect diagram.
T4: Cause and effect diagram.
LSF: For the pre-test? No persuasive writing?
T4: For the pre-test. No, no… no persuasive writing.

T1: I agree with you. The whole process in preparing takes the whole of yesterday's evening.
LSF: So the teachers did the preparation?

Time is not merely a resource management problem for many in the school; it is also an emotional problem. PSLE is perceived by many parents, teachers, and even school leaders, as an important closure to a child's primary school examination. A good PSLE score allows entry to a good secondary school and therefore a brighter life. Reducing revision time with the students touches the very emotion and sentiments of many teachers. According to Fullan (2007, p. 93), this factor is considered to be a characteristic of the school system, since schools adopt different testing methods. As Posner (1994) also pointed out, the role of student assessment in curriculum reform and initiatives are very important as teachers and students devote most, if not all, their efforts to whatever they believe someone will hold them accountable for. As a result, anything that contributes to the delay of the completion of the cycle is perceived negatively. This includes their perception of the subject-experts. The classroom teacher, with examination targets to meet and 'beleaguered' (Fullan, 2000, p. 117) with whole string of duties and meetings would find teaching from the textbook easier and more manageable. As Shepard (2000, p. 5) pointed out that 'dominant theories of the past continue to operate as the default framework affecting and driving current practices and perspectives'.

As Freire (1998, p. 68) mentioned, when they do not see the consistency of what is said and what is done, that is, they 'assume cynicism, which consists of opportunistically incarnating inconsistency'. School leaders must be aware of this reflection of the teachers' pedagogical content knowledge and beliefs. It is also important to note that this very lesson came out in the PSLE. The two teachers that did the research lesson were elated. They know that they had prepared and delivered the best lesson on the topic they possible could. This episode shows that LS has the potential to change attitudes, mindsets and teacher-beliefs about science teaching. They realize that inquiry should be part and parcel of the teaching of science. As such, LS has the potential to change "the core of educational practice" (Elmore, 2000, p. 30). It has the ability to make teachers understand, through experiencing it on their own, the nature of knowledge and the students' role in learning, that it needs to be actively accommodating and assimilating new knowledge with their already existing schemas, done best through inquiry and not just teacher depositing ideas in students' heads.

Conclusion

There are many challenges and factors affecting the implementation of LS in schools in Singapore. Besides understanding the characteristics of change and the characteristics of the school system, there is also a need to understand the culture and background of the educational institutions. In addition, understanding the practices of the educational institutions under study, and the SMK and PCK of its teachers, are also important in ensuring a smooth and effective implementation of any and every reform intended. Our study of the Science Lesson Study provided us with a rich example of the issues of the implementation of LS. It is important to note that these very issues highlight what might be symptoms of bigger problems within an institution.

This paper presents only our preliminary findings at this stage. As Birman et. al. (2000) pointed out that curriculum initiatives, of which LS is one, which has a longer duration of implementation, have more opportunities for teachers to learn actively about the subject content and available pedagogies involved in the teaching of that subject, and thus would be found more coherent with teachers' beliefs than do initiatives given shorter activities. Perhaps as what Eisner (1994) mentioned how a 'good teaching and substantive

curricula cannot be mandated, they have to be grown', so too must LS be given the time to be experienced, in order for teachers to understand its potential.

References

Buxton, C., & Lee, O. (2007). Bridging the divide between curriculum theory and practice for non-mainstream students in science education. *Journal of Curriculum and Pedagogy*, *Vol. 4 Issue 1*, pp 39 - 44.

Cobb, P., McClain, K., Silva Lamberg, T., & Dean, C., (2003). Situating Teachers' Instructional Practices in the Institutional Setting of the School and District, *Educational Researcher*, Vol. 32, No. 6, pp. 13–24

Eisner, E., (1994) *The Educational Imagination : On the Design and Evaluation of School Programs*. 3rd edition. New York: Macmillan, 1994.

Elmore, R., (2000). Getting to scale with good educational practice, in B. Moon, J. Butcher & E. Bird (Eds.), *Leading professional development in education* (pp. 30 – 51). Routledge/Falmer & The Open University.

Fullan, M. (2007). The New Meaning of Educational Change. 4th Ed. Teachers College Press, Columbia University.

Garet, M., Porter, A., Desimone, L., Birman, B., Kwang S., (2001). What Makes Professional Development Effective? Results from a National Sample of Teachers, American Educational Research Journal, Vol. 38, No. 4. pp. 915-945.

Mannheim, K., & Stewart, W., (1964). *An Introduction to the Sociology of Education*. London: Routledge & Kegan Paul, p. 33

Posner, G., (1994) The role of Student Assessment in Curriculum Reform, Peabody Journal of Education, Vol. 69, No. 4, Our Evolving Curriculum, Part 2, Summer, pp. 91- 99

Putnam, R., & Borko, H., (2000) What Do New Views of Knowledge and Thinking Have to Say About Research on Teacher Learning?, *Educational Researcher*, Vol. 29, No. 1, pp. 4–15

Shepard, L., (2000). The Role of Assessment in a Learning Culture, *Educational Researcher*, Vol. 29, No. 7, pp. 4-14

Shulman, L.S. (1986). 'Paradigms and research programs in the study of teaching: A contemporary perspective', in M.C. Wittrock (ed.), *Handbook of research on teaching*, New York: MacMillan, 3rd edn

Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15 (2), 4-14.

Shulman, L.S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, 57(1), 1-22.