Influence of Professional Learning Community (PLC) on secondary science teachers' culture of professional practice: The case of Bangladesh

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Abstract

While the current reform efforts in Bangladesh require a substantive change in how science is taught, an equally substantive change is needed in the culture of professional practice. This study will, therefore, investigate how science teachers' learning in a professional learning community (PLC) influences the ways in which

participant teachers learn about, and develop their practice. In so doing, teachers also work towards forming a professional learning community within and across schools. This study presents research from participating teachers' post teaching discussions and subsequent workshop discussions that together comprised their PLC. Data have been drawn from 14 voluntary participant science teachers who were formed into seven peer pairs, from seven schools in Bangladesh. Each pair of teachers was located at the same school. The results indicate that the post teaching discussions and professional workshops offered participating teachers opportunities to discuss their problems regarding resources, content knowledge, pedagogy and the learning environment in the classroom. The findings of this study ultimately carry implications for science teachers' practice and professional learning in secondary schools in Bangladesh, as well as for pre and in-service education for secondary science teachers.

Keywords: Professional learning communities; professional practice; science teachers; Bangladesh

Introduction

Professional learning communities (PLCs) emerge as a collective framework for professional learning within the context of a cohesive group that focuses on collective knowledge of inquiry (DuFour, DuFour, & Eaker, 2008; Stoll & Louis, 2007). PLCs work to improve the practice of particular groups of teachers through job-embedded learning. A PLC consists of a group of people who take "an active, reflective, collaborative, learning-oriented and growth-promoting approach toward both the mysteries and the problems of teaching and learning" (Mitchell & Sackney, 2001, p. 2). A PLC is also defined in terms of an "educator's commitment to working collaboratively in ongoing processes of collective inquiry and action research to achieve better results for the students they serve" (DuFour, et al., 2008, p. 14). In essence, a PLC is explicitly a place where caring, responsible people nourish others' learning in the context of authentic interactions (Manzaro, 2003; Miller, 2000).

In general, members of a PLC need access to collaboration, continuing leadership support, information, and their colleagues (Roberts & Pruitt, 2003). Clearly then, a highly directive leadership style and lack of meaningful opportunities to engage in learning activities can limit the capacity of schools to become learning

organizations in the form of a PLC (Lashway, 1997). Research indicates that the nature of schools as organizations typically do not encourage shared thinking; rather, teachers are generally free to make their own instructional decisions (Roberts & Pruitt, 2003). Moreover, teachers' isolation, lack of time, and the complexity of teaching present barriers to their continued professional learning (Lashway, 1997). However, school based professional learning communities can support and motivate teachers and encourage them to overcome problems associated with a lack of resources, isolation, time constraints and other obstacles they commonly encounter (Kruse, et al., 1994). PLCs offer teachers the possibility to connect with one another within and across the school in order to improve students' learning outcomes and their own professional learning (Roberts & Pruitt, 2009).

Problem of the study

It is a common experience of stakeholders that sharing knowledge and pedagogical experience is not part of a common culture among practicing science teachers in their schools in Bangladesh and that collegiality is typically lacking (Hossain, 2000). The country of Bangladesh, in which the research reported in this paper was conducted, is no exception. I illustrate this point through the following anecdotal example. In a school in Bangladesh, there were two secondary science teachers, Mr. Ahmed and Mr. Rahim (pseudonyms). They were responsible for teaching in grade seven and eight respectively. One day, Mr. Rahim noticed that he could not explain the concept of 'Total Internal Reflection' to his grade eight students so Mr. Rahim decided to ask his colleague Mr. Ahmed to explain this concept to him. Their conversation went as follows:

> **Mr. Rahim:** Hello, I would like to discuss with you about some subject matter. I am facing difficulty in explaining to my students.
>
> ***Mr. Ahmed:*** *No problem! I know that I am busy today, we will discuss it tomorrow.*
>
> ***Mr. Rahim:*** *It's Ok. Thanks*

In the meantime, Mr. Ahmed complained to other colleagues including the Head teacher about Mr. Rahim's lack of subject matter knowledge. Mr. Rahim heard about this complaint and decided not to go to Mr. Ahmed to discuss the subject

matter. Like Mr. Rahim, in many cases science teachers are confronted by the problem of explaining content properly to their students, but they find very little support for collaborating with others.

This type of incident works as an obstacle to sharing. It is also a very sensitive issue in relation to the image of the teacher in the Bangladeshi context. This type of image, as a content expert, is then a disincentive for teachers to observe each other's classes or to reflect on their practice in any public manner. In most cases, they do not share their knowledge with others. However, paradoxically, I found the teachers in this study enthusiastic to learn new knowledge and share with each other in the training sessions that I conducted as trainer. They also expressed a desire to change their school culture for their professional practice to enhance their teaching for better student learning. These experiences of listening to science teachers shaped my concerns for science teaching and learning in Bangladesh and impacted what I wanted to do, how and why as a science teacher educator in my country.

Purpose and Research Questions

The present study thus offers an exploration of how secondary science teachers' learning in a professional learning community influences the ways in which participant teachers learn about, and develop their practice. To address this issue, this paper sets two research questions. These are,

1. To what extent do participant science teachers engage in a Professional Learning Community?
2. How can establishing a Professional Learning Community influence the ways in which these teachers learn about, and develop, their practice?

Theoretical Background

Attributes of a PLC

The research-based literature on the attributes that characterize PLCs has grown over the last couple of decades and much of that literature centres on Hord's (1997) research-based characteristics of PLCs and the work of Dufour and Eaker (1998). At the same time, PLCs have also been influenced by Senge's (1990) notion of learning organisation and culture. Other significant contributions have been that of

Kruse, Louis and Bryk (1994), Berlinger-Gastafson (2004) and Patterson and Rolheeiser (2004). The following section discusses this literature in more detail.

Supportive and shared leadership capacity

Supportive and shared leadership capacity is one of the attributes that characterises professional learning communities (Annenberg Institute for School Reform, 2003; Berlinger-Gustafson, 2004; DuFour & Eaker, 1998; Hord, 1997; Kruse, et al., 1994; Patterson & Rolhiehieser, 2004; Senge, 2000). Shared leadership capacity empowers all members of a PLC to share in support of school improvement. One of the defining characteristics of a PLC is that of power, authority and decision making as being both shared and encouraged (Hord & Sommers, 2008). Shared leadership structures are important in PLCs. Hord (1997) emphasised shared leadership structures in which participants in PLCs have the ability to question, investigate and seek solutions for school improvement.

Shared mission, vision, values and goals

PLCs work as a solid foundation consisting of collaboratively developed and widely spread mission, vision, values and goals (DuFour & Eaker, 1998). Shared mission, vision, values and goals are also considered as a collective focus on and a commitment to student learning (DuFour, et al., 2008; Hord & Sommers, 2008; Kruse, et al., 1994). When schools work as PLCs, teachers find themselves with a fundamental responsibility for their students' achievement. To attain this shared purpose, participants are encouraged to be involved in the process of developing a clear and compelling vision that works as a guidepost in decision making about challenges they face in schools on how their collaboration must contribute to their students' learning.

Collective learning and its application

A PLC is a place where participants find opportunities to study together and work collaboratively (Hord & Sommers, 2008). Teachers expect that all students can learn at reasonably high levels as a consequence of participants' collaborative work. In practice, it does not happen due to different types of obstacles that students face outside the teaching institution. However, these opportunities help them to be involved in a continuous learning process and apply what they have learned to their practice. Such a collaborative process mainly emphasises the need to seek new

knowledge collectively (Hord, 1997). It is an expectation through this collective learning that an individual learns more than if they were learning independently.

Shared personal practice

Teachers need appropriate environments for their professional learning (Hord, 1997, 2004). Such environments value and support, "hard work, the acceptance of challenging tasks, risk taking, and the promotion of growth" (Midgley & Wood, 1993, p. 252). Shared personal practice is one of the attributes that contributes to the development of such a setting for teachers' professional learning and sensibly can be considered as one of the conditions that supports a professional learning community (Hord, 1997; Pickering, et al., 2007). In PLCs, members of the community discuss the situations and the specific challenges they face in their daily academic activities (Kruse, et al., 1994). They develop a set of shared norms, beliefs and values that form a basis for action (Hord, 1997, 2004; Kruse, et al., 1994). For this purpose, teachers review each other's practice (Hord, 2004) and behavior (Hord, 1997, 2004; Kruse, et al., 1994) in their daily practice. There is a focus on a "peers helping peers" process (Hord, 2004, p. 11), not on any evaluation of teachers' learning or teaching (Hord & Sommers, 2008). Teachers conduct this review through visiting each other's classrooms on a regular basis to observe, write notes, discuss their observation with their visiting peers, as well as through staff meetings and specifically designed planning sessions (Hord, 1997, 2004; Patterson & Rolhiehieser, 2004).

A commitment to continuous improvement

School improvement is a part of the overall culture of all school beliefs, values and practices (Alberta Education, 2006). In essence, school improvement emphasises the role of collecting data that establishes a base for decision making, problem solving and inquiry. Two factors are considered important in school improvement. These are internal support from other members of the community (Kruse, et al., 1994; Louis & Kruse, 1995) and documenting evidence for commitment within the community (Annenberg Institute for School Reform, 2003; Morrissey, 2000). Teachers must have support from the school community if they are to take risks with any new techniques and ideas. This is also a requirement for sustaining any serious and long-lasting change effort in their teaching practice (Kruse, et al., 1994) If that is the case, then teachers feel that they are supported in their effort to learn

new knowledge about their profession; new knowledge that helps them to make decisions about problems about, and inquiries into, their teaching practice.

Supportive conditions

Supportive conditions determine "when, where, and how the staff regularly come together as a unit to do the learning, decision making, problem solving, and creative work that characterise a professional learning community" (Hord, 2004, p. 10). These are basically considered as logistics of PLCs (Hord & Sommers, 2008). Kruse, Louis and Bryk (1994), Boyd (1992) and Berlinger-Gustafson (2004) worked to identify several categories that must be met in order for a PLC to be effective. The necessary conditions for physical and structural factors as mentioned by Kruse, et al. (1994) are time to meet and talk, physical proximity, independent teaching roles, communication structures, and teacher power and empowerment. The significance of the relational factors and human capacities which are considered social resources in a productive learning community is that they address teachers' enthusiasm to acknowledge feedback and work for improvement (Boyd, 1992; Hord, 1997; Kruse, et al., 1994).

Research Method

Strategies of inquiry

This study followed a qualitative approach to explore how secondary science teachers' learning in a professional learning community influences the ways in which participant teachers learn about, and develop their science teaching practice.

Research Design

Secondary school teachers in Bangladesh seldom receive recurrent training (Hossain, 1994, 2000). In most cases, training is conducted on an irregular basis depending on when funds are available, rather than the needs of teachers (Ministry of Education, 2005). Moreover, the teaching community also works in what appears to some to be a state of isolation with a lack of collegiality clearly apparent (Hossain, 2000). In this study, two science teachers from the same school formed a peer pair for classroom observation purposes. Seven such peer pairs worked in this intervention implementation process. According to the Figure-1, in this stage, firstly, all peer pairs conducted 'Teaching session-One' using a constructivist

teaching approach (the use of a POE). All pairs followed the same science teaching topics from the junior secondary level. Within each peer pair, one teacher taught while the other observed the peer's full lesson. For example, in peer-A, teacher 1 taught while teacher 2 observed the lesson. Secondly, both the teacher observer and the teacher reviewed their notes individually after the teaching session using the same classroom observation schedule. Thirdly, these individual reflections formed the basis of discussion between both teachers in which they shared, provided feedback and critiqued and challenged each other's observations. At the same time, I took field notes as a participant observer.

When all of the peer pairs had completed the classroom 'Teaching session-One', they came to 'Professional Workshop-One'. Issues about which they were undecided or were notable for some reason, including those that I had recorded as a participant observer during post-teaching discussion time for all pairs, were considered. I included all of these as issues to be discussed with the whole cohort of teacher participants for this subsequent workshop after each teaching cycle. At this stage, teachers worked with their science colleagues as a research cohort from nearby schools to discuss together the issues and their situations with the aim of improving their practice.

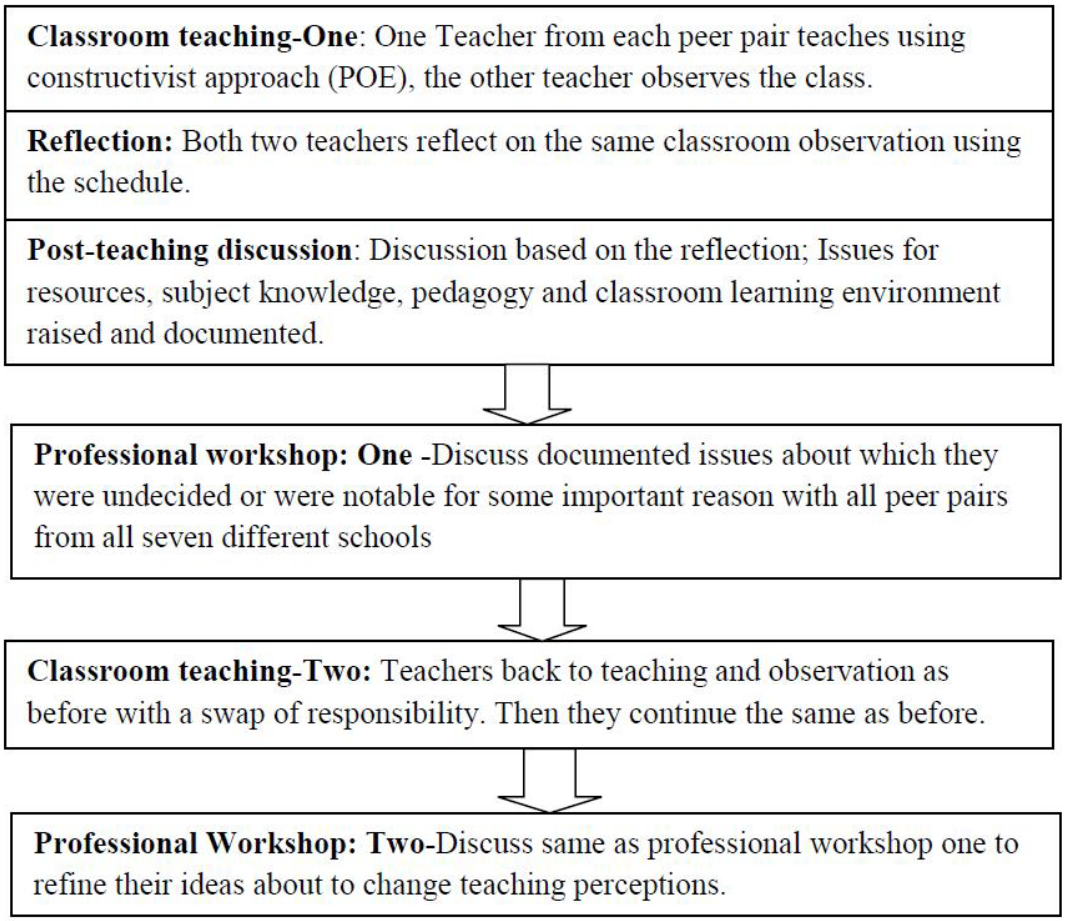

Figure-1: Outline of research design

After that, all participant teachers went back to a further round of classroom teaching and observation, 'Teaching session-Two' with a swap of responsibilities within each individual pair, i.e., in peer-A, teacher 2 then taught while teacher 1 observed the lesson. After that, they reflected on their notes using the same classroom observation schedule and then joined the subsequent post-teaching discussion as before. In this stage teachers found scope to apply their learning from previous sessions they had attended. They also started to construct a deeper understanding for the intervention process they were using in collaboration with their colleagues.

Participant teachers met for 'Professional Workshop-Two' to discuss again the issues about which they were undecided or were notable for some important reason, as recorded by them or myself from teaching round two. This workshop also

provided these teachers with opportunities to refine their ideas regarding their teaching perceptions and the culture of their professional practice. This set of activities together constituted one cycle. In this research, I conducted two cycles, in order to better understand the intervention and possible changes to teachers' practice.

Research Tool

Qualitative research tools were used in the course of this study in order to shape my understanding of the change in professional practice of these secondary science teachers. In particular, as a participant observer, I took notes to explore patterns and themes emerging during post teaching discussions and professional workshops. Basically, this paper focuses specifically on the use of one research tool, whereas the full study (Rahman, 2011) draws on a range of tools.

Sampling

I used 'convenience' sampling to select 14 secondary science teachers from seven nearby schools from those who volunteered to be further involved in the study. Consideration for inclusion was based on availability, easy recruitment and willingness to participate in the study (Mertens, 2010; Robson, 2002). Moreover, the nature of the intervention demanded participants from nearby schools within a local area. To fulfill that purpose, I selected seven nearby schools form Ashuganj UpaZilla of Brahmanbaria district of Bangladesh in order to make further involvement easy for participants and to attend the follow up professional workshops. Each individual peer pair then followed up through classroom observation, post-teaching discussion and professional workshops to see how ideas from different components of the intervention influenced their science teaching practice.

Data Analysis

Twenty-eight participant observers' comments for all peer pairs from their post teaching discussions and four professional workshops were analyzed using NVivo 8 to code themes and issues that contributed to the findings. The discussions were audio taped that were later transcribed. In this procedure, themes were identified from the qualitative data regarding different aspect of secondary science teachers'

culture of professional practice. These themes are the indications of changes in the culture of their professional practice and are described in the next section.

Results

This section discusses the participants' professional practice during the intervention. Teachers' practices will then be used as a way of identifying the changes in the culture of professional practice for the participating science teachers. This section mainly draws on notes from discussion and my participant observer's views both from post teaching discussions and professional workshops.

Results from Post Teaching Discussion

The participant science teachers found scope for discussion after completing their reflection on the observation schedule. During the discussion time, teachers found themselves both in agreement and disagreement with their colleagues, challenging each other's reflections or observations and sometimes feeling confused while engaged in debates about some aspects of their peers' teaching issues. The results reflect that in different situations these teachers felt nervous, confident or hesitant in discussing their teaching with their colleagues during the first teaching session. In most cases, teachers initially felt shy and hesitant and took longer in reflecting as they started the discussion with their colleagues at this point. According to Teacher 6, "I do not know how I can go; I am not used to discussing anything face to face with my colleagues before." In the same way, before starting the discussion during the first teaching cycle, Teacher 12 stated, "I am hesitating because I am not sure whether I did right or wrong in reflecting from my observation for his (colleague) presentation." These are their worries as they were not used to discussing issues with each other in a prescribed way. However, the results indicate that teachers began to change even from the second teaching cycle. According to Teacher 5, "Today I feel more relaxed as I know what we have to do." Teacher 9, during the third teaching cycle said, "I feel more comfortable than the first day; I understood that the discussion helps us a lot to clarify our ideas about teaching, so I like to share my mistakes and failures with my colleagues openly." These quotations reflect that as time goes on the teachers became more comfortable and relaxed in sharing and discussing successes or failures of their teaching with their colleagues. These results reflect how teachers can begin to change their culture of professional practice through discussion with their colleagues.

During the post teaching discussion time, teachers found that they agreed with some of the claims of their colleagues. Points of agreement between teachers varied in content, pedagogy, resources and learning environment across different discussion sessions. For example, during the second teaching session, Teacher 14 agreed with Teacher 13 that his emphasis was more on recall, or the recognition of the facts, rather than understanding of the concept of solution. His claim also included that students might understand how they can make saturated solutions from an unsaturated solution, but they still were not clear about how different variables (for example, solvent, solute, temperature) worked to make a saturated from unsaturated solution and vice versa. Teacher 14 then agreed that he needed to focus more on these issues. In the same discussion session, Teacher 13 was also convinced by the claim by Teacher 14 that his way of taking account of students' prior knowledge was not effective for the lesson.

Not all discussions were in agreement. Participants disagreed with certain claims or observations of their colleagues during the discussion. Disagreement between teachers also varied in relation to content, pedagogy, resources and learning environment. For example, Teacher 2 claimed that Teacher 1 fully followed the student textbook sequence during his session in the first teaching cycle. However, Teacher 1 did not agree with the observation. He said that as he tried to use the POE, the sequence of the student's textbook was automatically broken. As he felt he taught using the POE well, he did not think that he only followed the textbook sequence. These types of agreement or disagreement guided these teachers to clarify more about their practice through changing their culture of professional practice.

Sometimes, post class discussions offered teachers opportunities to challenge their colleague's practice. For example, during the first teaching cycle, Teacher 2 claimed that he did not observe whether Teacher 1 asked students to find any real life examples regarding the variation of pressure with depth. Teacher 1 then said that he did use examples. Teacher 2 then challenged him to repeat the examples. Teacher 1 was unable to recall any examples that he used in the class.

Teachers also discussed the confusion they experienced while teaching the topic, "the human brain" during the fourth teaching session. This was basically due to a mismatch between the diagram and the explanation in the text book. According to teacher 3, "I was struggling in grouping different parts of the human brain into

cerebrum, cerebellum and medulla oblongata, the information in the book confused me." In some cases, the Bangla name of different parts of the human brain increased the level of confusion for teachers. The above examples illustrate that as these teachers challenged one another's practice, it also helped them to clarify more about their own practice.

Results from Professional workshop

The four professional workshops mostly maintained a structure based around discussion forums after each teaching cycle and engaged participant science teachers in activities in which they found scope to reconsider their thinking both about their teaching and the culture of their teaching practice. At the same time, they found opportunity to discuss their own problems regarding their practice with teacher pairs from the other schools which is not common practice in Bangladeshi schools.

The participating teachers discussed the inadequacy, quality and importance of teaching aids in almost all of the workshops. During the first professional workshop, teachers discussed whether or not they needed any sophisticated teaching aids to make the concepts clearer during their post-teaching discussion in the first teaching cycle. For instance, teacher 6 said, "We need the sophisticated instrument; otherwise students will not learn properly or develop different conceptions." Teacher 4 disagreed with him and stated, "Our schools do not have enough funds to buy all the teaching aids. We need to find resources from our neighboring local school environments to use in our classes. For example, I think students will able to understand the basic concept of a 'simple pendulum' if we hang a 'stone' or a 'piece of brick' that works as a bob with a thread rather buying sophisticated steel or metal instruments from the scientific shop." Most of the teachers agreed with his statement. Teacher 9 stated, "I also believe that this is not a problem, we just need a proper plan. If we collect anything from our local environment and take care to preserve it properly, then we can use it in the following years." The above example reflects how a professional workshop offers teachers possibilities to share their experience about their practice and support their learning about new ideas in using teaching resources.

Teachers in different peer pairs experienced difficulty in reaching conclusions regarding content knowledge during their post-teaching discussion. Participating

teachers discussed their concerns regarding content knowledge and its organization during all four workshops with their science colleagues. These concerns included concept clarification, confusion arising about observed teaching, alternative conceptions, use of real life examples, and current ideas in relation to the respective concepts. It is notable that different peer pairs experienced different issues from the same teaching cycle, while in other cases, many of the peer pairs were confronted by the same problems. For example, all of the teachers found difficulty in matching the information and labeling the diagram in the text book in the fourth teaching cycle. At the beginning of the fourth professional workshop they discussed with their colleagues what they considered to be the proper grouping of different parts of the 'human brain' into three main parts, e.g., cerebrum, cerebellum and medulla oblongata. They also discussed the confusion arising from the Bangla names of these parts of the human brain. After a long discussion on this topic, Teacher 5 stated, "I feel more comfortable now. The discussion with my colleagues from other schools has helped me to minimize my confusion about this topic. I am sure next time I will be able to teach this topic more comfortably." All teachers appeared equally satisfied about this type of outcome from their discussions. It appears from the above examples that teachers attending the professional workshops found scope to clarify their science concepts.

Teachers liked to discuss different aspects of pedagogical understanding during the professional workshops. These discussions included clarification of the nature of a POE, teaching sequences, the use of multiple teaching strategies, strategies for teaching large class sizes, efficacy in teaching and opportunity for students' participation. Teachers also discussed effective teaching sequences. For example, during the second professional workshop most of the participant teachers emphasized the importance of progression in a logical sequence. For example, when teacher 8 was asked to explain how he designed his teaching sequence, he responded:

> I tried to find all the variables that are related to change an unsaturated into a saturated solution and vice versa - these are solute, solvent, temperature. I then tried to explain with the help of students how these individual variables control the preparation of saturated and unsaturated solutions. That sequence made my teaching easier; I think students also felt easy to understand all of these changes.

After his explanation, teacher 7 (his peer pair partner) expressed, "It seemed to be logical in presenting the topics. I also found the teaching very interesting as an observer of that teaching where he did not follow the textbook sequence." All other teachers were also impressed with his logical sequence. These results indicates that the workshops gave this teacher a chance to explain their pedagogical decision making, and this was helpful in stimulating discussion amongst the other teachers to help them know how they took into account text book sequence in his teaching.

Breaking Ice: Developing a culture of professional practice

At the end of the second professional workshop, two teachers wanted to discuss some of their difficulties with content knowledge. This became an issue in the third professional workshop. After some discussion, the group decided that each teacher would write one problem regarding their content difficulties on a sheet of paper and then place it in a box. Their responses were diverse and included: how to fish keep alive in the ice river in the winter in the polar region; N-type and P-type semiconductors; periodic table; total internal refraction and critical angle; and, meiosis and mitosis. Teachers were then invited to discuss their ideas about these content difficulties. For instance, to address how fish stay alive in an icy river, teacher 4 explained it in detail with the help of some of the other teachers. Following the explanation, I asked the participants:

> Facilitator: Have you understood what you wanted to know from this explanation?
>
> Teacher audience: (No response)
>
> Facilitator: How would we be able to know that you, who placed this issue to discuss, have understood the query?
>
> Teacher 2: (After silence for one minute, with hesitation) I placed this issue [on the table]. I am clear now.
>
> Facilitator: (After taking another topic from the box) Our next topic to discuss is "N-type and P-type semiconductors.

Teacher 5, then, made specific his problem and teacher 11 explained in detail how to respond to the situation. They continued with the rest of topics more comfortably.

The remainder of the professional workshop followed this problem solving approach. The above example illustrates how the teacher professional workshops helped teachers to 'break the ice' in sharing issues about their practice in more collaborative ways.

Discussion

The post teaching and workshop discussions sought to find out influences on the ways in which these teachers learnt about, and developed, their science teaching practice. These discussions ultimately led to a change in the culture of their professional practice in a number of ways. The following sections discuss how the establishment of a PLC offered these teachers the opportunity to develop their leadership capacities, share their mission, vision and goals in relation to improving their practice and focus on collective learning through shared personal practice, all of which supports their commitment to continuous improvement in their particular contexts.

The intervention process guided participant teachers to develop the capacity for building shared leadership through sharing their teaching practices which empowered them to share. Participant teachers engaged voluntarily in the learning process in order to enhance the quality of their teaching practice. The intervention process allowed them to observe a full period of classroom teaching, discuss their observations with their colleagues and attend the professional workshops. These various opportunities helped teachers feel more comfortable to share their feedback with their colleagues. The teachers enjoyed opportunities to share and critique their colleagues' practice and also to reflect on their own practice in relation to identifying positive and negative aspects of their teaching. It is evident that initially these teachers felt shy or hesitant in sharing; however, gradually they realized that it helped them to improve their teaching and they felt more comfortable in so doing in the latter part of the intervention implementation stage. Teachers' increased confidence may be due to collaborative activities where they found good support and ways to improve their teaching practices. The collaborative process allowed them to expand their capacity in developing a personal vision for their own teaching practice for enhancing student learning (Senge, 2000). As a consequence of their experiences, these teachers may well find in the future that they have now developed ways of working together as a teaching community based on collaborative approaches rather than a state of isolation.

The intervention process offered participant teachers the opportunity to join together in a structure where they were encouraged to question, investigate and seek solutions concerning aspects of their practice. This was evident when these teachers received constructive suggestions from their colleagues about how to improve their teaching. The discussions between colleagues allowed them to agree or disagree with the observations, even challenge each other's observations whenever they felt confused. These questions about their practice helped them to not only clarify their observations with their colleagues, but also to clarify their content knowledge, pedagogy and the learning environment in their classrooms. As a consequence, it appears as though participants also felt more comfortable in exploring their own problems regarding their own practice. Discussing and addressing their problems together, appears to have helped these teachers to develop a positive attitude towards establishing a professional learning community. The structure or frame used for discussions with their colleagues helped them to learn more from their colleagues and to raise their issues about their needs through this process of job-embedded learning (DuFour, et al., 2008).

Participant science teachers also showed respect, trust and wisdom in order to build their professional commitments. This trust and respect helped them to overcome the hesitation and inertia in sharing with each others. With this trust and respect, an environment was created whereby teachers found opportunities to challenge each other in order to clarify aspects of their teaching. Moreover based on this trust and respect for their colleagues, participant teachers explored their difficulties openly with their colleagues. Trust and respect therefore may have helped them to move from feeling shy to open sharing, and is important in developing a collective commitment to their students' learning rather privatization of their practice (Kruse, et al., 1994).

Participant teachers became involved in a continuous learning process and applied what they learnt to their practice. They engaged in reflecting on and clarifying their own teaching. The processes include agreement, disagreement and even challenging each others' observations. Their collective learning brought results that aligned with their expectations. For example, participant teachers found difficulty in matching the information and labeling the diagram in the text book in the fourth teaching cycle. Most of the post teaching discussion within individual peer pairs did not bring fruitful outcomes regarding this issue. They discussed with their colleagues what they considered to be the proper grouping of different parts of the

human brain e.g., cerebrum, cerebellum and medulla oblongata during the professional workshop. They also discussed the confusion arising from the Bangla name of these parts of the human brain. After a long discussion all participant teachers appeared equally satisfied about the outcome from their discussions. This instance illustrated the value of collective efforts for all participants as it mobilized each individual's energy (Senge, 2000). These processes encouraged collective learning through working together to overcome difficulties in explaining subject matter through organizing and structuring content appropriately. This process also developed an expectation among them that learning is ongoing and occurs as an integral part of routine practice.

The intervention process guided participant science teachers to share their personal practice with their colleagues. They found opportunities to support each other's practice through observing each other's classrooms, and discussing observed practice with colleagues within and across the schools. It is evident from teachers' comments that the scope of the intervention process provided them with an opportunity to integrate the experiences of other teachers into their thinking and practice. The process helped them to explore several challenges they faced in their regular practice. For example, confusion with science content understanding (variation of liquid pressure), language issues in science (bent or broken) and, lack of quality resources (labeling issues within a diagram) that were collectively explored during the intervention process.

Participant teachers in this study supported each other as a part of their commitment to professional development during the intervention process. It is clear that participant teachers received support from other colleagues and even from their students in planning for their teaching. In most cases they received support from their colleagues regarding the teaching aids before the class. In some cases they also discussed the sequence of a new teaching strategy and how they could make it more effective.

The schedule and structure offered by this intervention also helped to reduce the state of isolation amongst these teachers that is a very common complaint for teachers in Bangladesh. Participant teachers wanted to maintain this collaborative approach to their practice and suggested rescheduling their class routines to provide scope for regular collaborative meetings. They also suggested reducing their existing teaching load to provide more scope for sharing and observing each other's

teaching practice. The intervention process also encouraged these teachers to find new approaches toward communication structures with their colleagues. The processes utilized in this study may have helped these teachers to come together as a unit to do the learning, and support decision making, problem solving, and creative work in ways that characterize a professional learning community (Hord, 2004). These processes also highlight the importance of time and support for learning as variables for school improvement.

Conclusion and Implications

The establishment of professional learning communities influenced these science teachers' to engage in their learning. The process increased these teachers' confidence with collaborative activities which they found created supportive ways for addressing improvements in their teaching practices. Moreover, it appears as though participants also felt more comfortable in exploring their own problems regarding their own practice and needs through this process of job-embedded learning. Through collaborative work with their colleagues they felt supported in establishing their commitment to their students' learning. They became committed to finding the gaps or mismatches between their teaching and their students' learning and making decisions about the challenges they faced regarding develop their practice.

Participant teachers also found themselves accountable for identifying issues to discuss with their colleagues. The process also motivated and created a results-oriented approach that gave them direction in terms of building a collective commitment to a shared vision which in turn fostered their shared mission. Moreover, the collaborative activities through the intervention process influenced participant teachers to think in terms of supporting change in their culture of professional practice. Participant science teachers found the collaborative aspects of the process as positive for enhancing their practice. They also expressed their commitment to continue these activities. So it could be helpful to think about professional development programs that could support these activities in schools in terms of resources rather developing didactic professional development programs that have little impact on teachers' practice and are poorly regarded by participants.

These results then ultimately carry implications for these teachers' own professional learning, science teachers' practice and school administration in

secondary schools in Bangladesh more generally, and pre and in-service education for secondary science teachers.

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