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Cases of Exemplary Science Teachers' Professional Development Efforts

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Abstract : This qualitative research describes unique features of seven exemplary science teachers' professional development activities. Description of excellence in effective teachers' professional development efforts will provide some insights into required inservice initiatives and support systems for teachers' professional learning. Exemplary science teachers' professional development activities can be classified into four types: (1) practicing classroom supervision, (2) participating in voluntary communities of teachers, (3) playing instructional leader roles in teacher training programs, and (4) continuing one's studies at a graduate school. One of the common features of these exemplary teachers was that they can both articulate what makes teachers professionals and practice in accordance with their perspectives. These exemplary teachers not only improved their own classroom practices, but also participated actively in various professional communities to share their practical knowledge with their colleagues. The teachers have formed special-interest groups to investigate better ways of science teaching. They also took an active role in teachers' in-service education. Teachers' quality practices lie at the heart of classroom change. However, it's important to remember that there must be a support system that sustains and encourages teachers' initiatives. The implications for the support system to encourage teachers' professional development efforts are discussed.

Keywords : professional development, exemplary teachers, in-service education, classroom supervision

Introduction

There is ample evidence that well-prepared teachers produce more successful learners and effective professional development does make a difference in student achievement (NCTAF, 1997; Goodwin, 1999; Wenglinsky, 2000; McREL, 2001). The underlying assumption of this research is that the fulfillment of school education is possible with substantial instructions of each school curricular area. The substantial learning of any curricular area depends on each classroom lesson, which depends on what the teacher does in the classroom. Improving the quality of teaching continues to be the central focus of educational reform. That is, few may dispute that improving the quality of teaching is the key to any reform effort (CONNECT, 1999; Wenglinsky, 2000; NRC, 2001; McREL, 2001). Teachers' attitudes and commitment are crucial to whether or not any educational reform succeeds. Previous studies revealed that inservice teachers' professional development is a useful tool for improving classroom practices (Goodwin, 1999; Wenglinsky, 2000). That is, teachers' professional development activities are closely linked to classroom practice and emphasized as the primary vehicle in efforts to bring about systemic change in education (NCREL, 2002). Professional development is a key tool that helps teachers implement innovations and refines their classroom practice. The true interpretation and implementation of reform is made in the individual classroom (Corcoran, 1995).

Accordingly, in addition to preparing high quality teachers, we need to attend to maintaining high quality teachers through inservice teacher education. That is, we need to attend to in-service as well as preservice issues in improving teacher quality. Inservice teachers' professional development may make an important difference in the qualifications and capacities that teachers bring to their work (Darling-Hammond, 2000).

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Along this line, this study aims to illuminate what effective science teachers do to ensure their high quality teaching practices. That is, the purpose of this study was to describe the characteristics or practices of exemplary science teachers' efforts for professional development. Exemplary science teachers' professional development activities can be classified into four types: (1) practicing classroom supervision, (2) participating in voluntary communities of teachers, (3) playing instructional leader roles in teacher training programs, and (4) continuing one's studies at a graduate school. These four types are examined in this article.

A larger study[1)] associated with the results reported here investigated common characteristics of exemplary science classrooms and ways to improve science education (Kwak, 2002). In this study, I will discuss what makes these teachers exemplary by examining their consistent professional development aspect. The study aims to describe unique features of seven good-practice science teachers' professional development activities. Description of excellence in effective teachers' professional development efforts will provide some insights into required inservice initiatives and support systems for teachers' professional learning.

Methods

The selection of exemplary teachers began with a collection of effective instructions based on recommendation from various sources, including prize winners from teaching methods competitions, exemplary instructions featured on television or in books, recommendations from the Board of each school district, and recommendations from classroom teachers. In addition, a public notice about nomination of exemplary teaching was posted on bulletin boards of various teachers' professional communities. For one month since posting a public notice, around 50 nominations were arrived. With this first sample of instructions, a group of science education experts examined and selected 15 instructions based on a letter of recommendation, samples of lesson plans, available tape-recorded classrooms (or VODs appeared on the internet), and the teacher's research reports (if appropriate).

Among 15 chosen instructions (i.e., teachers), five teachers were not available for further data collection with various reasons, such as the teacher's illness, the principal's disapproval, or the teacher's hectic schedule. The selection committee was convened to decide the ranking according to the field observation priority. For the top seven cases, data from classroom observations, in-depth interviews with teachers and a group of students, a collection of instructional materials and expert-group meetings were used to extract common characteristics of instructional practices implemented by seven secondary-school science teachers. The interviews and audio portions of video-taped classrooms were transcribed for further analysis. Case studies illustrating seven teachers' personal background and features of classroom practices were documented in Kwak (2002). The transcription as well as the case study was then verified and corrected by each teacher through member checking processes. In this article, these teachers' efforts for professional development are examined.

Results

First of all, major driving forces for the good-practice teachers' efforts were examined. Two common driving forces were identified. One is the teachers' commitment to teaching and the other is supports from their colleagues who belong to the same professional community of science teachers. Exemplary teachers' enthusiasm for science teaching and learning as well as their dedication to the

1) This qualitative research is the second-year study of the same title, 'Improving the Quality of Korean School Education (I)'. For detailed information about the selection criteria of effective teachers, the common features of effective teachers' practices, and the teachers' recommendation for improving science education, refer to Kwak (2002).

teaching profession was the strongest impetus for their professional development efforts. With this enthusiasm, the teachers participated in various educational opportunities specific to science, including pursuing a master's or doctoral degree in science education. In addition, voluntary communities of teachers provided personal or emotional support and helped these teachers implement instructional initiatives.

Classroom supervision through online community

Tr. Jungho Shim[2] explained the current situation of clinical supervision in our secondary schools:

> I have been opening my classroom to the public once or twice every year so that teachers in my school district can observe and evaluate my teaching. That could be an opportunity for me to improve my teaching methods and classroom management. However, I hardly get any professional comment or critical feedback from those supervisors and other teachers who have observed my teaching. They just say 'you've done a good job' and that's it. But thats not what I expected from them. I expected them to offer specific advice based on a clear diagnosis of my teaching.

In general, classroom teachers rarely expect to learn anything useful from classroom supervision or as a result of opening their classrooms to administrators. Exemplary teachers are not afraid of constructive criticism from others. These teachers contended that the current classroom supervision system should change its focus from evaluation mechanism to helping mechanism. These teachers emphasized that a clinical supervision based on classroom observation is an effective means of monitoring and improving the quality of ones teaching. Exemplary teachers insisted that the most effective ways to improve teaching is to observe and experience other teachers' classrooms whereby teachers can learn about how new instructional methods and ideas can be applied in the real situation.

Tr. Taeyoung Kim has provided leadership as a powerful example of clinical supervision by disclosing his own classrooms to other teachers. He is also working extensively with colleagues to develop better instructional strategies and materials. Tr. Kim contended that in-service teachers need a clinical supervising system whereby their classrooms are observed and examined by experts. Tr. Kim has been leading an online teachers' community through his website. He is leading a cybercommunity so that any teacher can participated in this community without being restricted by time and space. That is, online classroom observations and communications enable teachers to exchange their ideas without spending time and money on travel.

> The title of my homepage is how to make science classroom interesting'. I wanted more teachers to visit and get together into my website. In the case of offline teachers' meetings or conventions, limited teachers who live close enough to a specific area could attend. Taking this into consideration, I want to build a cyberspace where teachers from all over the country can get together to share each other's information and opinions.

Tr. Kim argued that classroom supervision is the best way to improve one's teaching. He video-tapes his classroom activities and then analyzes his instruction with other teachers and science educators. In the cyber community built on his website, Tr. Kim has held supervision sessions with teachers, based on video tapes of what happened in his classroom. Through video analysis and discussion with other teachers and science educators, Tr. Kim examined the teaching strategies he used, which led

2) Any teacher's name in this article is a pseudonym.

to expand the range of instructional approaches teachers were familiar with. He assesses a video-taped recording of his own teaching based on which he meets regularly with colleagues and experts at his website to "keep a shared online journal". That is, Tr. Kim continually reflects on his teaching. Tr. Kim explains that "the main aim of this form of classroom supervision is for teachers to increase the range of strategies they could use in their teaching by observing my classroom."

Tr. Kim has been seeking constant feedback and evaluation of his lesson from science educators and college professors. He sends out his instructional materials along with the VOD of his practice to experts for comments on a regular basis. This is what makes his website as a clinical supervision site. As Tr. Kim put it:

> In addition to instructional materials that I developed, visitors to my website can read about and participated in the Q&A sessions where we can discuss about how to improve my teaching strategies. My website is more than a database of teaching and learning materials. Through watching my trials and errors and experts' feedbacks, I want other teachers to design and implement higher quality lessons by incorporating their own ideas.

The following quotes show an example of supervisory discussion between Tr. Kim and an expert who visits Kim's website on a regular basis. The extracts are taken from Q&A exchanges about Tr. Kim's video-taped lesson called 'volume, pressure, and temperature of gas (collaborative learning strategy)'. This could be an example of classroom supervision via an Internet cyber community.

> Visitor: Highly concentrated instruction and smooth classroom management are impressive. This class used students' drawing technique and Q&A discussion strategy together. I have a couple of questions that come into my mind. First, what was the purpose of the lesson, though? The motion of gas, Boyle's law, the difference between gas and liquid... all these contents are mixed up. You should have had a summary session at the end of the class.
>
> Tr. Kim: You're right. The original purpose of the lesson was to understand the motion of gas particles, but the video-taped class was behind of its schedule. Thus, I couldn't cover all those contents with enough time... so I just summarized the major points of each topic. That's why there are various contents. On the other hand, I attempted to implement an integrated approach through the syringe experiment. In fact, when you observe the motion of gas particles, there could be various questions and approaches. I designed an instructional scenario to sustain students' curiosity. I thought that following students' questions step-by-step will help to keep their attention.
>
> Visitor: Another trifle thing (maybe it's important). You talked about how to prove the fact that collisions between gas particles prevent the piston of a syringe coming down although students push the piston downwards'. It's a logical approach but I am not sure that's an appropriate approach for 7th graders. I mean, the motion of air particle cannot be "proven", but "explained" that way when you describe that kind of phenomenon.
>
> Tr. Kim: I agree on that matter. Even scientists had searched the best way to explain that unobservable phenomenon, rather than searching for a way to prove that phenomenon. I just wanted to utilize students' thoughts as a starting point of my lesson....
>
> Visitor: Your another experiment is not appropriate to demonstrate the fact that gas molecules are moving in all directions. Actually, after watching the experiment, I heard that some students said gas molecules are going upwards! When you interpret the result of this experiment, you might reinforce one of the students' common misconceptions, that is, gas molecules have

a tendency of going upwards. I can't think of an alternative explanation, though. In addition, it could have been better if you used more audiovisual materials to enhance the visibility of the experiment.

Tr. Kim: To tell the truth, I was not confident of the logical connection of my lesson. As you pointed out, I might have reinforced students' misconception... What about making a holiday pillow using dry ice? ... I will think over better ways to represent that concept.

As can be seen in the above quotes, discussions cover from the correctness of science content covered to validity of the implemented teaching strategies. This conversation is professionally rewarding for both Tr. Kim and the visitor. On his website, Tr. Kim also loaded a set of teaching and learning materials used in his video-taped lessons and students' work samples so that other teachers could carry out the lesson in their own classrooms. He also provides reproducible students' worksheets, a collection of assessment tools, and teaching tips that include such information as students' typical misconceptions, ways to confront students' misconceptions, how to implement jigsaw cooperative learning strategies and suggestions for using specific instructional materials.

I usually prepare an instructional scenario in narrative format that shows the whole context of my teaching. By reading my instructional scenario, teachers can imagine how I taught a specific topic. It's much more vivid than a traditional lesson plan. The best way to improve one's teaching is to observe someone else's teaching, which is rarely possible. Therefore, I decided to provide video-taped lessons along with instructional scenarios.

Tr. Taeyoung Kim wants to become a master teacher who works for novice teachers by observing their classrooms. With Tr. Kim's encouragement and help, a couple of teachers also video-taped their classrooms and have shared their VODs with other teachers via Tr. Kim's website. Tr. Kim's case demonstrates the possibilities of using the Internet for constructing, communicating and examining teachers' classroom practices and their professional knowledge. As Tr. Kim put it:

Although teachers hesitate to disclose their own classrooms, they want to observe others' teaching. That's why I am posting video-taped lessons on my website. If I load my videotaped classrooms on my website, somebody is going to watch my teaching. And somebody is going to comment and leave some feedback to my bulletin board. I have kept thinking about how to make better teaching and learning experiences. There are many teachers out there who have excellent ideas and implement best practices. If possible, I want those best practices known to others. With more experiences, I want to observe other teachers' classrooms and then exchange some teaching tips with them.

Tr. Youngjune Park contended that inservice teachers need clinical supervision system whereby teachers' classrooms are observed and evaluated as a way of enhancing instruction. Superintendents of the school district must see themselves as clinical educators who provide expert critique on teachers' instructions. Classroom supervisors need to be trained in observing instruction and then giving teachers instructional feedback. They also need to model effective practices for teachers through professional development sessions if they expect teachers to implement those practices in their classrooms.

We need superintendents who observe and provide feedbacks to classroom teachers. Under the current system, all those superintendents in each school district are doing some kind of administrative work, not that of clinical supervision. Personally, I don't want to be promoted to do administrative work even in the future.

According to Tr. Park, under the current supervision system, "it is rare to exchange any professional dialogue about teaching for those teachers who actively seek opportunities to improve their practice".

> In my opinion, at least for those who want to examine their own teaching through clinical supervision, there should be a cooperative supervision system. Furthermore, the supervisor's role should be more one of mentor, rather than one of judge or evaluator. Rather than imposing new practices on teachers, there needs to be a supporting environment where teachers does not have to hide their concerns.

Exemplary teachers explained "although lesson plans or laboratory manuals are excellent quality, teachers can't implement effective lessons as described in those instructional materials" without observing or experiencing those lessons (Tr. Taeyoung Kim). Tr. Jaewon Kim explained the importance of classroom observation as follows:

> Reading about how to implement a lesson is not enough. Teachers themselves need to experience or at least watch those lessons where they can figure out how each instructional material is introduced and how each step of an experiment is carried out. If teachers can see methods used by other teachers, they can take the effective strategies utilized by others and implement them in their own classroom. That's why video-recorded lessons along with instructional materials should be provided. Most of instructional contexts and strategies are hardly understood only through reading.

In addition, exemplary science teachers contended that through mentoring or peer coaching, faculty collaboration should be encouraged. Exemplary teachers contended that in the case of classroom supervision, supervisors need to be more knowledgeable about science and current pedagogical approaches. Unless a supervisor's background is in science education, she will have a hard time to tell content inaccuracies in an Earth science class or possible misuse of laboratory equipments and methods in a biology class (Danielson & McGreal, 2000). That is, a science classroom supervisor's background should be in science education so that she is knowledgeable in content-related pedagogy.

Participation in voluntary communities of teachers

Classroom teachers are isolated from fellow teachers because teachers' work is carried out almost entirely apart from others. However, achieving real instructional change calls for deep inquiry into science content and pedagogical content knowledge, which can't be done by oneself. Teachers need support mechanism that allows teachers to experience model activities, discuss an innovative approach to teaching, and work out classroom applications (Zemelman *et al.*, 1998). First of all, teachers need to view teaching approaches "not just as private preferences or personality traits, but as strategies to be compared, analyzed, and then adapted to one's own style" (Zemelman *et al.*, 1998).

Exemplary teachers try to work collaboratively with other teachers. These teachers were building teacher communities and networks where they can interact and support one another. They organized a small interest or research group of teachers within the school or local district. With the support from these collaborative groups, these teachers have gained confidence and builded up trust while experimenting with new ideas and strategies of teaching and learning. Their willingness to share their ideas and assist other teachers with difficulties led to form or lead teachers' voluntary communities and networks. Through these teachers' networks, exemplary teachers also volunteered to be mentors to new teachers. Tr. Taeyoung Kim contended that "the best way to grow up professionally is to participate in face-to-face teachers'

meetings."

> I think, for teachers' professional growth, few activities are more powerful than joining with science teachers' communities, such as 'sin-kwa-ram'. It's hard to improve your practice all by yourself. In other words, we learn not so much from our own experience. Teaching is not the kind of job that you can self-teach without others' guidance. The faster you learn about seniors' know-hows of effective teaching, the faster you become an effective teacher. Therefore, teachers' informal or formal communities and networks are the most important mechanism. Consistent interactions with other teachers is the key to substantive growth as teacher.

Exemplary teachers contended that inservice teachers must seek improvement because "teaching is a kind of job that always demands more learning and innovation" (Tr. Youngjune Park). Subject-level teams of teachers in the same school building have a regular meeting where they have evaluated their instructional strategies and shared ideas with one another.

For example, Tr. Youngjune Park have led a science teachers' community in the Incheon district for the last 10 years. This Incheon science teachers' community was formed in 1992 to meet the needs of teachers who wanted to learn about Tr. Park's newly developed laboratory equipments and experimental designs. Since its establishment, this community shard its expertise with other teachers and investigated alternative experiments and laboratory equipments. This teachers' community has held Science Fair for teachers each year where members of this community share and report what they have researched and developed for one year. Teachers in this community can exchange ideas, develop new instructional methods, and investigate new methods of teaching. Tr. Park describes the community's whiches as follows

> We developed and revised lab manuals and teachers' guidebooks based on our own experiences. Through our community's science fair, we provide teachers with opportunities to conduct all these experiments and to discuss how to reconstruct science textbooks for a better learning opportunity. Besides, veteran teachers also help new members incorporate effective experimental strategies into their practice.

Tr. Jungho Shim argued that "most of the inservice teacher workshops and training courses are of little help." Therefore, Tr. Shim has designed and implemented a number of teacher workshops and teacher reeducation programs within his school or district, including 'a computer study group'. Based on this voluntary teachers' collaborative work, Tr. Shim earned research fund with which his team designed a website featuring video-taped lessons along with useful instructional materials.

Tr. Byoungmoon Kim has been actively presenting his work at professional conferences. Tr. Kim has developed various computer simulation programs and instructional modules to facilitate effective teaching. Furthermore he shares all his products with other teachers by opening his website to the public. Tr. Byoungmoom Kim contended that "just like the NSTA in the US, we also need to organize teachers' professional community whereby we can share teaching materials and carry out teacher reeducation programs."

Tr. Sunghee Kim has been operating 'the Amenity science teachers' research group' in the Pusan district. Since its establishment in 1999, the Amenity group has invented interesting experiments other than those presented in science textbooks, operated Amenity experiment classes for the public, and implemented a variety of hands-on environmental education programs for students. In addition, the group also organized voluntary teacher-training programs where teachers can have hands-on experiences with various Amenity experiments. The group also publishes various resource books that explain how to design and implement

Amenity experiments.

Tr. Younsoo Lee has also joined with 'the E-school teachers' community' where his colleagues *analyze problems in the school or students' learning*, and talk about their successes and problems. He explained that through these research meetings teachers describe to each other what was working and what the obstacles were in their recent classroom improvement efforts. As Tr. Lee put it:

> Whenever we get together, we share each other's experiences with students and talk about one's failure. We have had seminars at regular intervals where we share how to make science class interesting and amusing. We meet regularly to investigate better ways to address pending instructional issues. We try to keep others from repeating the same mistake.

Teachers' professional communities range from the regional network to the nationwide science teachers' association organized around a specific subject matter or teaching approach (e.g., teachers' research group on cooperative learning). The goal of these voluntary communities is for teachers to learn from each other. In addition, these informal study and support groups of science teachers have provided the opportunity for self-chosen professional development. Various science teacher networks and professional communities tend to focus on specific subject-matter and seek to deepen teachers' understanding of content and new teaching strategies.

Playing instructional leader roles in teacher training programs

One of the common traits of these exemplary teachers was that they wanted to not only improve their effectiveness but also help their colleagues do so as well. These teachers were expected to provide professional development workshops or seminars for other teachers. In other words, exemplary teachers are dedicated to serve as a resource to their less-experienced colleagues.

Tr. Taeyoung Kim has been "willingly participating in any teacher training opportunities he was invited to give a lecture or demonstration of his *ways of teaching*." He has tried to "model how to use the kinds of instructional tools he wanted other teachers to use with their own students". As he put it:

> Whenever possible, I am trying to differentiate my session from others provided by university professors. As I am presenting what I have been doing and listen to what teachers say, I come to *have a strong responsibility for teaching, which* makes me work harder to improve my instruction.

Tr. Sunghee Kim is also presenting her community's products and activities whenever necessary. She contended that "without these conventions and invitations, I doubt if I would have had the motivations to spread our group's ideas and to share our experiments with others." These opportunities provided Tr. Kim with important reinforcement and incentive for continuing her professional growth and development.

> Just before I got a phone call from Y university asking to give a lecture to preservice teachers about our "Amenity science teacher program". I also got two phone calls yesterday. One is from B university and the other is from a kindergarten association asking to present our community's activities. ... whenever opportunity comes, I just go there and emphasizing why our teachers need to take the initiative in protecting the environment and how to raise our students who know the importance of the natural environment. All these invitations are another support for me to keep on with our activity.

Tr. Younsoo Lee is also working for the teacher training program of the Kyoungkee school district as an appointed lecturer for invention activities. At his own school, Tr. Lee has organized a Science Fair every year. Furthermore, he has spreaded his

school's science fair among other schools as he offered advice for how to implement science fair at the school level. Tr. Lee emphasized that "through all these presentation opportunities and experiences, I am also enhancing my professionalism as a teacher."

That is, according to these exemplary teachers, their activities as teacher educators allow them to self-evaluate, reflect, and assess their own instructional improvements. These exemplary teachers are willing to share their experiences and insights in any meeting or inservice session. They viewed the development of other teachers as one of their most important responsibilities. By performing these roles, exemplary teachers contended, they are "being held accountable for their performance as implementers of various forms of instructional methods and teachers' professional development".

Continuing one's studies at a graduate school

One of the common features of exemplary teachers was that they had a career-long conception of teachers' learning. Therefore, most of these exemplary teachers have been attending a graduate school to pursue advanced degrees or learn more about pedagogical content knowledge as teachers.

For example, Tr. Byoungmoom Kim is a doctoral student for the last two years. Even after earning his doctoral degree, Tr. Kim wants to work as a classroom teacher so that he can continually work for developing better teaching methods. Tr. Byoungmoom Kim contended that "I am trying to get a doctoral degree not to teach college students but to teach effectively secondary school students."

Tr. Taeyoung Kim have attended at graduate school during vacations. After earning a master's degree, Tr. Kim wants to get actively involved in peer supervision and to work for improving classroom instruction. He wants to stay at classrooms even after finishing his graduate school work. On the other hand, Tr. Kim contended that "we should provide teachers' access to university courses without requiring them to enter into a degree program."

Tr. Yoonsoo Lee got a master's degree in physics education. Tr. Jaewon Kim already got a doctoral degree in science education. He also wants to remain as a secondary school teacher rather than to be a college professor. Tr. Jungho Shim also got a doctoral degree and has conducted various action research projects with his collaborative group of colleagues.

In sum, some of the exemplary teachers have put the theories learned in their graduate school into classroom practices. Furthermore, they are developing as teacher-researchers. These teachers' participation in action research will in turn encourage the sharing of effective practice and professional knowledge across the wider educational community (Zeichner & Noffke, 2001).

Conclusions

Exemplary science teachers contended that "teachers are professionals not because they have unique content knowledge, but because they have theories for how their students learn based on their own experiences" (Kwak, 2002). One of the common features of these exemplary teachers was that they can both articulate what makes teachers professionals and practice in accordance with their perspectives. These exemplary teachers not only improved their own classroom practices, but also participated actively in various professional communities to share their practical knowledge with their colleagues. The teachers have formed special-interest groups to investigate better ways of science teaching. They also took an active role in teachers' in-service education. Teachers' quality practices lie at the heart of classroom change. However, it's important to remember that there must be a support system that sustains and encourages teachers' initiatives. The implications of this study can be summarized in four points.

First, principals' administrative support for the changes should be underlying a teacher's profes-

sional development efforts. Behind exemplary teachers' constant efforts there was the principal's positive support for an individual teacher's initiative. School principals should be involved in a variety of school reform efforts and networking of teachers. Furthermore, they must encourage teachers to attend seminars and take risks to improve their instructional techniques. For teachers' best practice, "a strong, encouraging principal who knows curriculum, welcomes innovation, and believes in teachers" is vital(Zemelman *et al.*, 1998). Without school leaders' constant support for change, individual teachers' initiative will fail. Accordingly, principals need to provide the necessary support to ensure that teachers can fulfill their crucial role in the school.

Second, there should be support for teachers' group activities and teacher networks where teachers discuss their practice and share ideas with their colleagues. Most of the exemplary teachers in this study have organized or participated in teachers' professional communities that provides teachers with positive support. Participation in the professional communities was another strong driving force for these teachers. Teacher networks and teachers' voluntary communities have high credibility with teachers, and appear to have positive effects on their motivation, pedagogical content knowledge, willingness to take risks, and commitment to improvement (Darling-Hammond, 2000; Kwak, 2002). Therefore, the board of education or the Ministry of Education & Human Resources Development should explore how to support teachers' communities or networks, including financial support. Sustaining teacher networks requires ongoing commitment of time and financial resources associated with these collegial activities. In addition, there should be strong incentives for teachers to work with their colleagues. To provide the funds to help sustain teachers' community, the board of education can invite teachers' community to join in a research project contest or to participate in action research that aims to investigate improving school science and science education.

Third, we need to explore how to empower and support those classroom teachers who are instructional experts. Good-practice teachers deserve recognition for their hard work and effort for improving instruction. Therefore, we need to develop a rewarding system that properly acknowledge best-practice teachers. Policymakers could thus improve teacher quality by providing more opportunities for teachers to receive professional development (Wenglinsky, 2000). In addition, provided that teachers receive adequate professional development, they might be provided with rewards for carrying this emphasis into the classroom. For teachers who implement effective classroom practices, financial bonuses or advanced certification (e.g., master teacher certificate) could be offered as a reward for their efforts. Best-practice teachers should be recognized and given responsibilities commensurate with their abilities, such as supervising beginning teachers or working for professional development programs. This directly leads to the next assertion.

Lastly, we need to provide experienced teachers with opportunities to work as teacher educators. Teachers emphasized that most of the inservice teacher training programs are rarely relevant to teachers' professional development needs. Teachers contended that they need role models with whom they can explore new classroom practices. The failure to use exemplary teachers to lead professional development contributes to the division between research and practice (Corcoran, 1995). Therefore, professional development programs should draw on the expertise of experienced teachers by employing them as teacher educators who can translate theory into practice based on classroom realities. Teacher (re)education institutes should respect the expertise of accomplished teachers and include experienced teachers in the design and implementation of professional development programs (Corcoran, 1995). Teacher (re)education programs need to develop leadership capacity

among inservice teachers by allowing exemplary teachers to play leadership roles with their peers instead of bringing in outside experts.

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