Development of a Product Oriented Group for Mathematics Teachers Professional Growth[1]

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A research group consisting of some mathematics education scholars and school teachers has been formed to build a website which intended to combine both theories and practices of mathematical teaching since 2002. There were three working stages: video-tapping realistic math teaching, developing video discs of different themes, and designing e-Learning. The group members learned knowledge of teaching by actual participating. On the other hand, the products enabled the audience to get professional development in knowledge of both mathematics and teaching. Management process of this group and effects upon the participants and users will be presented and discussed in this paper.

I. PREFACE

A group of people has been meeting every other week since 2002. What have they been doing? They have been working on their own professional development and helping junior high and elementary school math teachers to improve their professions.

Why did they gather together so frequently? It is a long story. We should retrace to the

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math curriculum reform happened in Taiwan eighteen years ago.

A constructivism-approach math curriculum was implemented in junior high and elementary schools in 1993. Since then, children's cognitive development and their problem solving strategies became the main concern. It was a big change for most in-service teachers because they needed to shift from the one-way teaching style and putting heavy emphases on math knowledge to create a teacher-student interactive environment in the classroom. Making their teaching more efficient, teachers had to grasp more about teaching materials, teaching strategies and children's learning so as to provide themselves with enough effort and confidence to deal with math teaching and children's diverse thinking. Therefore, we published a series of 13 books on "Analysis of Elementary School Mathematics" talking about the developmental process of math knowledge and children's cognitive levels between 2000 and 2006. Members of the group thought that the series should be useful for teachers for teaching. However, since those books were hard for teachers to read, it seemed that they were not be able to help teachers to understand the context of different math concepts. Thus, based on the following two reasons:1. solving the problem of un-readability of the above mentioned reference books 2.helping teachers to grasp teaching materials and context in math curriculum, the group followed the theory of peer supervision (Chiu, 1995) to improve teachers' professional development and promote their quality of teaching via observation and sharing teaching experience. In this way, it can also solve the worry that Lee (2005) mentioned 'in-service teachers considered teaching theories and teaching practice to be two separate things.' At last, we decided to present the contents in forms of the realistic teaching videotapes which were transcribed and reorganized.

It is not convenient for a teacher to observe other's teaching and investigate teaching materials when he encounters difficulties. On the other hand, it is also inconvenient and time-consuming for most of the teachers to go to the library to find out what he needs for solving teaching problems. On-line learning is a quick way to let teachers reach those resources. Due to the rapid development of information technology and increasing frequency of people using website, e-Learning has been applied in the fields of education and training. According to their own needs and speed, learners can choose different ways and contents of learning, thus learning is no longer restricted to fixed time and places. It is a device of creating a learning environment and improving the efficiency (Wu & Lin, 2007). Recently, there have been many researches done on investigating databank of teaching in order to provide teacher training courses and many cases of presenting some subtle teaching skills for teachers' professional growth, too (Reynolds, 1989; Lee, 2005). Those digitalized films of specified math teaching play an important role in connecting theories and practice (Dolk & den Hertog, 2001). Fruedentale Institute proposed that there were three important events of cultivating math teachers: reflection, narration and construction.

MILE (multiple interactive learning environments) project of Fruedentale Institute digitalized videotapes of realistic elementary math teaching which were also used for teacher training. MILE helps pre-service teachers to study theories of instruction via observation, reflect their original view point of teaching and construct their own teaching styles. In other words, besides the practical learning environment provided, MILE also offers learners representations of realistic teaching to form their own knowledge of teaching (Goffree & Oonk, 1999; 2001). It happened to be the idea of micro-teaching that videotaped the realistic teaching to let teachers repeatedly observe the whole teaching process. Then, knowledge and skill of teaching were divided into some independent tasks which could be practiced individually, afterwards, the whole teaching could be completed successfully (Lee, 1997). That means, teachers can be inspired by realistic teaching and reflection to clarify their beliefs and change their teaching behavior finally.

Teacher's professional development means that a teacher shows the ability and willingness of improving his professional knowledge and skills (Erffermeyer & Martray, 1990). Since the development of teacher's professional knowledge is a slow process (Lee, 2003) both pre-service and in-service teachers should continuously work on it. Math teachers' professional knowledge can be divided into content knowledge, pedagogical knowledge and knowledge of students' cognition (Huang, 2000). Fennema & Franke (1992) proposed a model for research on teachers' specific knowledge in the math classroom, consisting of three kinds: knowledge of mathematics, pedagogical knowledge and knowledge of learners' cognitions in mathematics. The group chose knowledge of mathematics, pedagogical knowledge and knowledge of learners' cognitions in mathematics to be the main focus for teachers' professional growth. Tsai (2004) proposed that strategies of knowledge management included building knowledge databank, encouraging teachers to formulate the individualized learning plans, constructing regulations of group and knowledge sharing, strengthening action research and team teaching, setting up the learning culture of schools, building evaluation rules for applying and developing knowledge, etc.

In order to help school teachers promote their ability and willingness in peer learning, a research group consisting of mathematics educators and in-service teachers was formed to videotape a series of realistic classroom math teaching. To set up an e-Learning databank to provide teachers with an optimal digital learning environment was our final goal so that teachers might use them freely at any time. In the bank, there would be teaching films, teaching plans and teaching analyses. Glatthorn (1987) described five types of cooperative development as follows:

1) Professional dialogue: It refers to discussion of the research results with professionals, combination of the results with experience and leading to a change of attitude.

2) Curriculum development: An applicable teaching plan designed by peer-teachers.

3) Peer supervision: A group comprised of teachers assists peer teachers to improve their teaching qualities by means of clinical supervision.

4) Peer coaching. It means a group of teachers try to enhance their professional knowledge through discussion on teaching.

5) Action research: Teachers work together to develop some strategies of solving problems.

Teachers of this research group met with professors periodically and discussed with peers about their teaching plan and teaching activities. They improved their professional knowledge via professional dialogue, curriculum development and peer coaching. Users using the resources in the data bank would not only combine theories and practice but also discuss with other teachers. They improved their professional knowledge via professional dialogue and peer coaching. The written record for each meeting at every developmental stage was kept. Thirteen teachers of the group were interviewed and a focus meeting was held to understand what they thought about professional growth. Two workshops of using on-line resources were held at National Academy for Educational Research (NAER). The participants of the workshops were asked to fill in a questionnaire to get their feedback. A qualitative method was used to analyze them. In the following section, we are going to discuss the developmental stages of this group, performance and growth of the members and growth of the users. Therefore the e-Learning courses and teachers' professional development will be explained.

2. DEVELOPMENTAL STAGES

Members of the research group consisting of research fellows in NAER, math education professors and in-service teachers met every other Saturday afternoon. Professional dialogues were undertaken and data were collected in a qualitative way.

The whole process could be divided into three stages, the first stage aimed at collecting lots of realistic teaching films; the second stage focused on developing video discs of different themes; the third stage started to construct an e-Learning curriculum. Each stage is described in detail as follows:

2.1. Stage of collecting and accumulating realistic teaching films

Prior to the first stage, we invited some in-service teachers who were interested in this task. Their willingness was the most important consideration. Those who wished to improve their professional ability were invited as long as they showed the enthusiasm for

learning and contributing to the math education.

Several important and difficult mathematical topics, such as length, fractions, ratio and proportions, etc. were explored. Depending on each attendant's teaching grade and text-book used at that semester, we decided every teacher's teaching focus, such as indirect comparison of length, unit change in length, addition and subtraction of fractions with different denominators, equivalent fractions, and so on. In other words, we had planned the structure of each film first and followed by arranging each teacher to teach topic of different theme. The whole teaching process was videotaped by professionals, in this way a large amount of teaching films were collected to record their 'realistic teaching.' It was the main task at this stage. Each teacher had to write down his own teaching plan and dis-cussed with others. Taking other participants' suggestions, he revised his teaching plan and did the teaching which was videotaped. Right after the teaching, the teacher talked about his teaching, such as how he arranged the teaching activities, what he expected for students' reactions and how the students behaved in that session, etc. His talk was also videotaped. He had to write down his reflection on teaching afterwards. Generally speak-ing, the research group paid respect to each teacher's teaching style because the realistic teaching was what we wanted to show to the audience. We hoped that the audience could reflect on their own teaching after observing the others.

The research fellows and professors were made responsible for the curriculum context, design of teaching activities, and development of children's cognition; while the math teachers were responsible for designing teaching activities, teaching demonstration and sharing their teaching experience. Since all the teachers followed their own teaching schedule and used whatever grade students they were teaching in that semester, they demonstrated how to teach a certain concept in the unit. Therefore, the teaching time and teacher-student interaction were both realistic in daily teaching. There were 99 units of films from198 teaching hours in three years. Then, those films were transcribed. NAER published the series of 'Exploring Elementary and Junior High Math Teaching Material & Pedagogy' consisting of teaching films, transcriptions, reactions to teaching and reflection afterwards between 2004 and 2009. The topics include length, decimals, ratios and pro-portions, geometry, etc.. We hoped that the series would serve as cases of discussion for professional development so that teachers could grasp the subtleties of teaching.

2.2. Stage of developing video discs of different mathematical topics

The group reviewed the tasks and the effects at the first stage from the necessity of teachers. We found that those publications could let teachers watch the realistic teaching of various topics in a single class session , while the connections among different topics behind the teaching, for instance, the connections among 'preliminary concept of length',

'composition and decomposition of length', 'indirect comparison of length', and 'unit change of length' were not explicit. Therefore, at the second stage, we developed a series of 'Video Discs of Math Teachers' Professional Development' which introduced the teaching process of various topics together with some realistic classroom teaching examples. Its purpose was to enhance teachers' comprehension of math topics and to develop teaching skills.

At this stage, we discussed about the context of math teaching, children's problem solving strategies, and scripts of video discs. There were three lines working simultaneously:

(1) Each teacher was responsible for a theme topic. He had to read the related references, collect data and design the outline of the program.
(2) The professors were responsible for constructing structure of math teaching materials including the order of presentation and focus of learning.
(3) Other members investigated the correctness of sentences, pictures and math concepts keeping the view points of the users in mind.

Each script was a product of these three interwoven lines. When the whole group agreed that it could be understood by the audience, then the script was passed to a program service company to be cut as a program. In each script, several suitable pieces of realistic teaching from the previous stage were chosen to be the examples which would help the audience understand.

Starting from 2005, six programs were completed, they were 'length', 'time', 'life and mathematics', 'decimals' ,, 'ratio and proportions' and 'concept, addition and subtraction of whole numbers. Several others are still under-working, such as 'multiplication of whole numbers', 'division of whole numbers', 'concept, addition and subtraction of fractions' and 'geometry', etc.. For an example, 'life and mathematics' which showed the connection between daily life and mathematics is quite different from the other programs. It does not follow the mathematical structures and students' cognition as the others do. The goal was to let students learn how to derive some related math problems from daily life, and in turn, to acquire certain math concepts and solve the daily problems.

2.3. Stage of constructing an e-Learning curriculum

Although video discs provided teachers with more resources, their quantities were often limited. For the sake of implementation, the group started to reconstruct those video discs to be an e-Learning curriculum so that the users could read freely. Its goal was to build an internet auxiliary learning environment.

At this stage, the group met periodically, too. The professionals collected and analyzed related theories. They also tried to offer some self-evaluation of items and contents for

extension learning. The teachers were responsible for arrangement of those data related to teaching practice. After a thorough discussion, we selected several important pieces of realistic teaching films of different topics to edit them to be 'teaching practice'. Thus, an integral process of teaching on that very theme would be presented to the audience. Combining the series of books "Analysis of Elementary School Mathematics" which served as the bases of learning theory with 'self-evaluation' and 'extension learning', we built the Website of "elementary school and junior high school math teachers' professional development." The user could choose different courses such as 'length', 'time', etc. according to his needs. Those courses would help both pre-service and in-service teachers who could get the pre-service training, in-service training and professional development via self-studying.

Tasks of the second and third stages formed a cycle since we had to add more e-Learning courses which used the previous films taken at the second stage. We believed that the effective way of knowledge management would make the dissemination of knowledge available. So far, there are six courses on the website, i.e. 'length', 'time', 'life and mathematics', 'decimals' , 'ratio and proportions' and 'concept, addition and subtraction of whole numbers. Among them, 'life and mathematics' had a different presentation from the others due to its different way of organization.

3. PROFESSIONAL GROWTH OF GROUP MEMBERS

It was a hard task because the group members had to work at the weekend for a long period of time. Besides the discussion at the meeting, they were responsible for reading references and writing scripts. Only those who were enthusiastic and willing to contribute could undertake in this work for such a long time. We called them 'group members' in order to differentiate them from the other school teachers.

There were two kinds of data collected:

1) Interview with individual group member. Questions asked were such as his purpose of joining this group, reasons for continuously participating, what he got at each stage and what he got out of the interactions with professionals and peer teachers.
2) Discussion during the focus-group interviews. Emphases were put on their ideas about teaching, teacher's role in teaching, strategies of promoting students' problem solving ability and ways to evaluate students' learning.

Due to the rich dialogue among members of the group, they gained much progress in professional development. Those participants loved this way of professional growth since we could sense that they had very obvious progress via 'professional dialogue', 'curricu-

lum development' and 'peer coaching'. The attitude of active participation together with the environment of mutual caring and supporting in the group leads them to progress in both knowledge and ability. We are going to discuss their development of attitude, affection and knowledge as follows:

3.1. Development of Attitude

Almost all the group members were very much interested in math education and math teaching. They had never joined any similar group before, some of them were a little bit hesitant whether they could not finish their tasks, but they did have the actively learning attitude and needs for professional development. Those were the reasons made them catch the opportunity and try different tasks of teaching, while we could read from the following interviews:

T4: "I enjoy learning and teaching mathematics. But learning mathematics does not mean that my students understand whatever I teach. I hope to learn in the group of math teachers in order to promote my ability in teaching." (20080725 interview with T4)

T3: "I do not know what I can do in this group. I am not sure what my contribution will be. But I am sure that it is a rare opportunity of learning since I can learn from many professors, gain some professional development in math education and try to get some quite different teaching experience." (20080718 interview with T3)

T9: "Participating this group is a good chance to enhance self-learning. Although teachers can attend the in-service training activities at their schools, we often learn knowledge in pieces. It is an unusual group because there are always professors' instruction and peer-teachers' discussion."

Most members who joined this group worked very hard at each stage because they expected to "learn by doing and promote their effects of teaching.' (20080702interview with T10) or to "increase their mathematical knowledge and teaching skills" （20080703 interview with T11). Moreover, some of them wanted to transmit their own experience, so that they could contribute to math education:

T1: "I have the opportunity to participate this group and gain growth in my teaching; therefore, I do wish to transmit what I get to other teachers who also want to promote their teaching skills." (20080710 interview with T1).

Those members with ample teaching experience understood the importance of promoting professional abilities. They all had strong learning motivation, so they were ready to face such a long-term and hard work and to join the group adapting the developmental model (Jones, Lubinski, Swafford & Thornton, 1994). They were grateful for having the

opportunity to join this group, thus, they did their best to help others who also wanted to gain professional growth.

3.2. Development of Affection

As long as those teachers joined this group, they felt that they joined a "warm and supporting group. We could sense the mutual care, encouragement and support as we were in a family." (20080706 interview with T12). "Teaching strategies were often shared" among peers. The best thing was that "those professors solved our perplexing problems in teaching so that we were able to recognize the math teaching materials from a broader, higher and deeper view." (20080701 interview with T13). They often "reflected on their own math teaching and got some new sights." (20080702 interview with T10), and sensed that "there were a group of partners helping me improve my teaching." (20080729).

Those participants also gave us the following reasons for continuously attending this group, including "no matter how I behaved, I was always confirmed from the feedback I received. I obtained knowledge. I had a good time with others. Those were reasons for me to stay in this group."(20080713 interview with T9), "Continuous encouragement and suggestions from the members made me step forward. It was the greatest factor pushing me to participate so far." (20080708 interview with T7), "It was a significant task. I could not only improve my teaching ability, also had fun in teaching. It was worthwhile for me to engage in." (20080701 interview with T13), "I got much precious knowledge from professors' ideas and suggestions which made me familiar with the teaching materials. On the other hand, I found that the students' reaction was improved." (20080704 interview with T6).

It is obvious that the warm interactive atmosphere and whether they had got something were the two important factors that would attract them to join the group continuously. Those in-service teachers did need to be confirmed and encouraged when they encountered difficulties. Joining the research group was an extra burden besides their school works, but the effort they took was worthwhile as it was significant for themselves, school teaching and math education.

3.3. Development of Knowledge

The members also pointed out what knowledge they had gained. At the stage of collecting and accumulating realistic teaching films (design teaching activities), their main growth was in knowledge of math teaching. At the stage of developing video discs of different mathematical topics, they got more in knowledge of mathematics and students' cognition since the discussion was focused on mathematical structure and students' cognition (see Table 1).

Review upon the tasks of those participating teachers made us know that those members were working partners on the one hand, and they got development together on the other hand. Due to the atmosphere of mutual assistance, supporting from their friends and family, needs for professional development, improvement in teaching knowledge and skills, they were willing to work hard for such a long time. As no other short or long-term teachers' workshop could achieve such a goal, so those teachers were glad to enhance their professional development via the way of 'learning by doing'.

Table1. Development of knowledge

Stage	Analysis of Members' Growth	Original Interview Transcription
Collecting and Accumulating Realistic Teaching Films (design teaching activities)	At the stage of designing teaching activities and video-tapping the realistic teaching, each participant had to face the fact that his teaching was going to be video-tapped and to discuss his teaching with other members. In the process of discussion, he studied the structure of teaching materials, the context and students' thoughts. He learned to investigate and revise his teaching by observing others' teaching. He could sense his change. That was professional development.	• I studied and reflected repeatedly upon the design of teaching activities. When I watched videos of my teaching, it seemed that I was looking at a mirror because I had seen the defects of my teaching. Ideas and suggestions given by the professors made me understand more clearly about the context of math teaching and re-investigate my own teaching. I tried to bring theories into classroom. (20080708 interview with T7) • I considered only how to transmit knowledge to students in my teaching before. Although I also cared about teacher-students interactions, I instructed them to learn the skills of solving problems only. After the discussion with professors many times, I understood the structure of teaching materials and children's thinking model. I understood their ideas through the process of video-tapping. I felt that I made progress.

(Cont.)

Stage	Analysis of Members' Growth	Original Interview Transcription
Developing Video Discs of Different Mathematical Topics	At this stage, teachers encountered an un-experienced challenge, *i.e.*, when they were writing scripts of films, they had to consider more aspects than teaching, such as the focus and context of the teaching materials. Taking decimal as an example, it had to include the mathematical concept, four operations and algorithms. Those materials had to be analyzed according to learning theory, to be explained through a realistic teaching. And students' possible problem solving strategies would be discussed according to their cognition. Those teachers should also choose suitable pictures to be presented which might be animation or equations for explaining a math concept and proper words of explanation. They had to use those colloquial expressions accepted by the audience, too. Such a training made the members be clearer about the mathematical concept. They might understand mathematical knowledge and students' cognition thoroughly.	• Writing scripts of math teaching films was a quite different task which could push me to reflect on my teaching and organize the context. It was a very good training to make my thought more rigid. (20080704 interview with T6) • The advantage of writing scripts was to make me have a more clear recognition on context. It was helpful to organizing teaching materials and teaching itself. The process of making films according the context was interesting. The arrangement of sound and presentation of pictures were the experiences I had not had before. I learned how to say something in a simple and clear way. (20080721 interview with T2) • The most gain I got was clarifying many paradoxes in math concepts and students' ideas of problem solving. I understood more clearly about the math knowledge which I thought it was simple or took it for granted before.

4. PROFESSIONAL DEVELOPMENT OF WEBSITE USERS

After publication of the series of 'Video Discs of Math Teachers' Professional Development', teaching supervision groups in Taichung county, Chian-hua county and Yi-lan county had used those videos to organize the workshops of teachers' professional development. It was rather difficult to collect participants' feedback of using them although

more and more teachers had known and used the resource. Therefore, we tried to collect feedback from those participants who attended workshops held at NAER. They were required to browse through the website 'Math Teachers' Professional Development' during the workshop. They pointed out that the most special features of the website were the presentation of realistic teaching, offering reference resources and being able to study promptly.

Some of them said the following:

'It is easy to operate and convenient for reading. The teaching films were organized by segments so that the users could watch the real teaching process and read the teaching plans at the same time. It attracted us to learn by browsing through the website.' (ratios and proportions 003)

'Observing the real teaching was more realistic and specific than reading the teachers' manuals.' (decimals 00)

'I got a clear idea about the math teaching process. Other's teaching process was internalized to be my own experience.' (decimals 021)

'It awoke us to pay attention to the details in teaching and to offer students with correct concept so that they could grasp easily.' (decimals 033)

'All teaching films were provided with written transcription. It was helpful for self-learning because one could stop watching to read the references whenever he needed thinking. On the other hand, it was a great help for sharing and reviewing since all the documents could be downloaded.' (ratios and proportions 023)

'It helps to enhance the depth and broadness of teachers' knowledge of math curriculum. I found and accumulated abundant useful teaching resources.' (ratios and proportions 027) 'Teachers could browse the website and fetch whatever they needed for teaching at any time, even during the break. In other words, they could do it instantly.' (decimals 001)

It was encouraging to know that those teachers had given us the positive feedback about the website. Because combining theory and practical teaching had been what we aimed for and letting teachers browse the website at any time was our final goal for developing the e-Learning curriculum. Therefore, it was proved that teachers would have higher learning motivation while they could observe the real teaching process. The group was happy and felt good because it showed that we were in the right direction to fulfill teachers' needs. Therefore, it was worthwhile for us to put such a great effort on it.

On the other hand, teachers had much expectation to the website, such as:

'It would be more convenient for us to search if the films could be assorted according to grades and（the first and the second）semesters.' (decimals 018)

'Please provide us with some excellent sample test items about various learning contents so that we may learn how to write test items correctly. Then, we are able to know what our students really learn and in turn to reflect our teaching.' (decimals 042)

'Please collect some examples concerning either student or teachers' misconception be-

cause it is important to clarify the misconception.' (ratios and proportions 030)

'I hope that you can continuously develop and include the other topics of elementary school mathematics. Please introduce this website to all teachers so that they may understand and use it since it helps a lot to their teaching.' (decimals 008)

'Encourage teachers to browse or to form groups to discuss what are stated on the website.' (ratios and proportions 038)

Those suggestions will be the important references for our following works. Since most teachers loved to watch the realistic teaching, they suggested to add more content. But it was a time consuming work to develop the film, on the other hand, members of the group could only work on it at the weekends or after classes in the evening. The product shown on the website was accumulated through our continual effort. Enhancing the program to be perfect will certainly be our expected goal but it must take a long time to reach.

5. CONCLUSION

The professional growth which members of the group gained and the harvest that users of the website gathered manifested that different teachers could get professional development via different pathways, *i.e.*, the group members learned by doing, the users did self-learning by browsing through the website. The group members had more opportunities of discourse with experts and peer teachers than the users. Therefore, they could solve their problems encountered in teaching immediately. They were able to involve peer teachers' teaching experience and practice in their owning teaching. The members got a higher level of professional development than the users because they could accumulate their practical experience in form of "curriculum development". Their development of knowledge and skills would be certainly deeper and last evermore. The facts proved that any in-service teacher could improve himself as long as he grasped the opportunities of learning and worked hard.

Echoing to the educational innovation and tides of the era, teachers have to improve their professional qualities continuously in order to satisfy their necessities of teaching. At this time, our website provides teachers with the related resources. We do hope that teachers can use it. But we strongly suggest that teachers form learning communities to strengthen their power rather than studying alone since learning communities can assure the effects and continuity in their professional development (Chou, 2006). Those teachers join the community can observe the teaching films, study the mathematical structure and students' cognitive structure first. Then, they can take some issues for professional discourse and exchange their ideas. In this way, the materials on the website might be used

more effectively; consequently, it could reach the goal of 'peer coaching' that Glatthorn (1987) proposed in cooperative development.

Finally, we strongly suggest that more researchers investigating the related topics can do some case studies of the individual user or evaluate the effects of the website upon the users.

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