Lesson Study in Mpumalanga Province, South Africa

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1. Introduction

The role of teachers is crucial to implement curriculum reform (Leu, 2004; O'Sullivan, 2004; Schwille and Dembélé, 2007). In the classroom, teachers are the agents who implement the curriculum which curriculum developers intended. Through this practice, students can achieve the outcomes of the intended curriculum. In this process, the teachers interpret and digest the concepts and contents of the curriculum first. Then they make plans of actual lessons based on their understanding. The capacity of teachers is one of critical elements to implement a new curriculum.

Teacher professional development for curriculum reform requires new approaches because a new curriculum requires new approaches to student learning such as active learning, the use of higher-order thinking skills, student-centered lesson and a constructivist base. Approaches to teacher learning also should change in similar ways to the approaches to student learning (Leu, 2004). The goal of teacher learning is to help teachers become reflective practitioners and teachers are prepared to be empowered professionals. The learning of teacher should be active and participatory, school-based in which all teachers participate, facilitate by teacher themselves, focused on a teacher's knowledge and realties of classrooms (Leu, 2004). In developing countries, O'Sullivan (2004) indicated the usefulness of an adaptive approach which examines the reality of the school and which experiments with strategy that focuses on student achievement within limitations based on her case study in Namibia. Hardman et al. (2008) also pointed out that school based training is more likely to have an impact than a traditional cascaded top-down approach based on their case study in Nigeria.

Lesson study from Japan is an activity by teachers and for teachers to their lessons through their collaboration. Lesson study is a continuous cyclical process and consists of planning the lesson, presenting the study lesson and reflecting on the lesson to improve the next lesson. Lesson study approach satisfies the condition of professional development required for curriculum reform. Stigler and Hiebert (1999) indicated following characteristics of lesson study lead improvement; gradual, focused on students' learning and how to support learning, at classroom situation, improved by teachers themselves and learning from experiences. Saito et al. (2008) described school-based in-service training which consists of lesson observation and reflection introduced in Vietnam to support introduction of new curriculum Baba and Nakai (2009) indicated that lesson study in developing countries is different from previous top-down model of teacher development since lesson study is flexible and diverse professional development which focuses on teachers' collaboration and their creativity. Ono and Ferreira (2010) proposed an alternative form of professional development using Japanese lesson study.

In developing countries, lesson study was introduced through Japanese technical cooperation projects. Saito et al. (2006) and Saito et al. (2007) described lesson study practices for mathematics and science teacher education projects implemented in Indonesia. They indicated that the lesson underwent three changes: (1) a change in the academic base of the lessons; (2) a change in the structure of the lesson by the introduction of experiments or manual activities and discussions; (3) a change in the reactions of students during the lessons. They also pointed out two challenges: (1) participants narrowed interest in the students' learning processes; (2) the necessity to involve the entire school in lesson study. Baba and Nakai, (2009) pointed out that one of challenges of lesson study in Zambia is that the ideal image of lessons which is the target of lesson study is vague and not shared among teachers and teacher trainers. Ono and Ferreira (2010) described the introduction process of lesson study in Mpumalanga, South Africa.

This study described how the lesson study was implemented after the introduction and how the teachers and teacher trainers accepted lesson study for teacher professional development. This study also focused on the contents of science study lessons and reflections of the lessons to ascertain how new curriculum was implemented and discussed by science teachers.

2. Background

2.1 Implementation of New Curriculum in South Africa

South Africa introduced a new curriculum which embraces outcome-based education after national elections were held. It was subsequently revised to make it more user-friendly and published as the Revised National Curriculum Standards (RNCS) (Department of Education, 2002; Rogan and Aldous, 2005). Chisholm and Leyendecker (2008) pointed out the main reasons for the problems during implementation of the new curriculum in South Africa. These were confusion about the meaning, content of the concept and intended changes, and the fact that consequences of the intended instructional practices were not of a piece with local classroom cultures and realities. They also indicated that curriculum changes probably work best when curriculum developers acknowledge existing realities, classroom cultures and implementation requirements. Rogan (2007) pointed out that new curriculum is defined at the macro level by some kind of central authority such as a Department of Education and should be implemented at certain grade levels in the prescribed year. Schools were given no say as to when and to what extent they would comply with these requirements. Rogan and Aldous (2005) reported how the new curriculum was implemented. They conducted a case study in secondary schools in Mpumalanga Province. They found that the implementation of the new curriculum in classrooms was still low in 2002 based on classroom observation and teacher interviews. Bantwini (2010) reported that most science teachers in primary schools of Eastern Cape did not implement RNCS in 2006 and few of them mentioned that they introduced group work and allowed students to take control of their learning.

2.2 Lesson Study in South Africa

The introduction of lesson study in Mpumalanga province was started by the project called "Mpumalanga Secondary Science Initiative (MSSI)" (Ono et al., 2007; Ono and Ferreira, 2010; Ozawa et al., 2010). MSSI was a joint project of the Mpumalanga Department of Education (MDoE), the Japan International Cooperation Agency and the University of Pretoria. The aim of MSSI was to improve mathematics and science teaching through teacher retraining and to establish provincial wide in-service training. MSSI was an "Experience-Sharing Model" in which exposure of group of individuals form developing countries to the relevant experience of the cooperating country rather than receiving on-site instruction by dispatched experts. The target outcome would be the formation of an autonomous system and practice utilizing experience (Nagao, 2007). A small group of teacher trainers and teachers from South Africa had short-term training in Japan.

In Phase 1(1999-2003) of MSSI, target teachers were those who taught mathematics or science for the General Education and Training Band (GET), Grade 8 and 9 in secondary schools. The retraining was done though a sequence of activities according to a cascade model. It began by empowering mathematics and science "curriculum implementers" (CIs), who acted as teacher trainers through six-week group training in Japan at Hiroshima University and Naruto University of Education (NUE). After their return, the trainees organized district level workshops. Heads of mathematics and science departments (HODs) of the secondary schools attended the district level workshop in their respective districts. The HODs conducted training sessions for their colleagues at their schools (Nagao, 2007).

In Phase 2(2003-2006) of MSSI, mathematics and science teachers of the Further Education and Training Band (FET) also became the target of the project. In this phase, CIs and cluster leaders (CLs) of FET were empowered in a six-week group study in Japan at Hiroshima University and NUE. They organized regional workshops for other cluster leaders (CLs) who were teachers represented clusters which were groups of schools geographically close together. The CLs conducted training sessions for their colleagues in their clusters.

The first lesson study, which included study lesson and post lesson reflection, was conducted in September 2000. The initial outlook of lesson study for professional development appeared bright in 2001, but lesson study was not practiced again in workshops until 2007 because the National Department Education barred all workshops during the school term (Ono and Ferreira, 2010).

MSSI was terminated in March 2006, but Japanese efforts to support the professional development of South African teachers continued until 2008. Mathematics and science CIs and CLs for GET were empowered by six-week group study in Japan at Hiroshima University and NUE. The training in NUE was focused on lesson study. Also a research team of NUE visited Mpumalanga twice a year to understand how the lesson study was implemented and to support dissemination of lesson study through conducting cluster lesson study workshops with ex-trainees from April of 2006. In September 2008, MDoE conducted lesson study dissemination workshops with a NUE research team. The half-day workshops were held at five different venues in four regions. Each program mainly organized by ex-trainees included an introduction of lesson study, study-lesson observation, a reflection session of the observed lesson and plan for future implementation of lesson study. The participants, from 60 to 70 in number, were teachers, CIs, principals, and local educational administrators.

3. Method

This study employs the case study method. The data have been collected in three ways:

(1) To understand how the concept of lesson study was accepted and implemented by teachers, semi-structured interviews for CIs and CLs were conducted in June 2009

(2) To understand how the science lessons were planned and conducted based on the new curriculum, observations of study lessons were conducted from September 2009 to September 2011.

(3) To understand how lesson study was implemented and how it could be improved, observations of reflection sessions were conducted from September to September 2011.

Interviewed CIs and CLs were introduced to the author from MDoE officers and interview sessions were conducted in four regions of Mpumalanga where lesson study dissemination workshops were conducted in September 2008.

Study lessons and reflection sessions for this study were observed at lesson study workshops which were organized by CIs of four regions. MDoE requested that CIs hold lesson study workshops to promote lesson study when the author visited Mpumalanga. Therefore the teachers who demonstrated their lessons seemed to plan lessons very carefully and to present lessons which they wanted to show others including officers from MDoE and Japanese researchers. These lessons might be very different from those which the teachers implemented in their daily practices.

4. Acceptance of Lesson Study by Teachers of Mpumalanga

Eleven CIs and seven CLs from four regions were interviewed in July 2009. The result of the interviews indicated that few schools and clusters disseminated lesson study. At least twenty two clusters of Natural Science or Mathematics at the intermediate phase (Grade 4-Grade 6) or senior phase (Grade 7-Grade 9) of GET began to conduct lesson study in June 2010 out of 268 clusters (Table 1). Some CLs of these clusters were ex-trainees who were empowered by six-week intensive training for lesson study in NUE. Others learned lesson study in dissemination workshops held in September 2008. Although MDoE promoted lesson study of Mathematics, Natural Science clusters, only 8.2 % of the clusters began to conduct lesson study.

From the interviews of teachers and CIs, it was obvious that they considered lesson study could contribute to the professional development of teachers. Both of teachers and CIs thought that the planning process in lesson study was very important because teachers could share ideas with each other about content knowledge, teaching methodology, and assessment strategy. Teachers who were not good at certain topics could get content knowledge from other teachers who were strong in the topics. Teachers indicated that the misconceptions and achievement of students could be observed in the presentation of the study lesson. Teachers considered reflection sessions were important because other teachers shared different perspectives on the lessons that are presented. Also the teachers considered study lessons presented to other teachers as a kind of model lesson which reflected the concept of the new curriculum. So they thought that they could grasp real images of the new intended curriculum through lesson study practices.

Table 1 Number of clusters which conducted lesson study in July 2010

	Math Intermediate	Math Senior	NS Intermediate	NS Senior
Bushbuckridge (14x4=56)	1		5	
Elhanzeni (15x4=60)	3		2	5
Gert Sibande (18x4=72)	2	2		1
Nkangala (20x4=80)				1

5. New Science Curriculum in South Africa and Characteristics of Natural Sciences Lessons

5.1 Revised Curriculum of South Africa

The Department of Education of South Africa provided revised C2005 for GET (from Grade R to Grade9) as “ Revised National Curriculum Statement For Grades R-9 (Schools) ” in 2002 (Department of Education, 2002). The natural sciences learning area statement mentioned that meaningful education had to be learning-centered and help learners to understand not only scientific knowledge and how it was produced but also the contextual environmental and global issues that were intertwined within the learning Area.

In RNCS, the fields which scientists study had been grouped into four main content areas; “Life and Living”, “Energy and Change”, “Planet Earth and Beyond” and “Matter and Materials”. “Life and Living” focused on life processes and healthy living, on understanding balance and change in environments, and on the importance of biodiversity. “Energy and Change” focused on how energy is transferred in physical and biological systems, and on the consequences that human needs and wants had for energy resources. “Planet Earth and Beyond” focused on the structure of the planet and how the earth changed over time, on understanding why and how the weather changed, and on the earth as a small planet in a vast universe. “Matter and Materials” focused on the properties and uses of materials, and on understanding their structure, changes and reactions in order to promote desired changes.

Three Learning Outcomes which addressed different competencies were stated as follows.

Learning Outcome 1 “Scientific Investigations” states that the learners will be able to act confidently on curiosity about natural phenomena, and to investigate relationships and solve problems in scientific, technological and environmental contexts.

Learning Outcome 2 “Constructing Science Knowledge” states that the learner will know and be able to interpret and apply scientific, technological, and environmental knowledge.

Learning Outcome 3 “Science, Society and the Environment” states that the learner will be able to demonstrate an understanding of the interrelationships between science and technology, society and environment.

5.2 Characteristics of Observed Science Study Lessons in Lesson Study Workshops

Eighteen science study lessons were observed which were conducted in lesson study workshops at primary schools or secondary schools from September 2009 to September 2011. These lessons included four lessons of “Energy and Change”, nine lessons of “Matter and Materials”, two lessons of “Life and Living”, and three lessons of “Earth and Beyond” (Table 2).

An activity-based approach was identified in all study lessons. Teachers provided various activities such as experiment, observation, group discussion, data processing and presentation by students. Teacher prepared apparatus and materials for experiments, worksheets which learners followed, the large piece of papers on which students wrote their opinions, and visual aids such as cards and posters. In all lessons, students were seated in groups when the lessons started. In most lessons, groups of students conducted the experiments by themselves. When the amount of apparatus was limited, the teacher conducted experiment but students still collected data and discussed results in groups. Students seemed to be very active and eager to conduct practical work. They also seemed to be interested in practical work and to be impressed by the phenomena which occurred in the experiments.

These study lessons were examined according to the learning outcomes of RNCS. Learning Outcome 1 (LO1) includes three assessment standards; “Planning investigations”, “Conducting investigations and collecting data” and “Evaluating data and communicating findings”. For “Planning investigations”, all experiments and observations in the observed science lessons were given by the teachers and students did not plan the experiments or observations to solve the given questions. Students also did not clarify questions by themselves. Although the teachers asked students to predict outcomes before the experiments in eight lessons, students seemed to be confused in most cases because they could not understand what they predicted. For “Conducting investigations and collecting data”, students conducted experiments in twelve lessons and students conducted observations in two lessons. In two lessons, teachers demonstrated the experiments to the students. All lessons of “Energy and Change” consisted of experiments conducted by students. Out of nine lessons of “Matter and Materials”, seven lessons of consisted of experiments conducted by students and two lessons consisted of demonstrations by the teacher. Out of two lessons for “Life and Living”, one lesson consisted of observations. Out of three lessons for “Planet Earth and Beyond”, one lesson consisted of experiments conducted by students, one lesson consisted of observations of a model of the earth, one lesson consisted of drawing a pie chart using data. For “Evaluating data and communicating findings”, sharing of findings of experiments was observed in seven lessons out of twelve lessons which included students’ experiments. Two lessons in which teachers demonstrated experiment did not consist of sharing of findings. Two lessons in which students conducted observation did not consist of sharing of findings. Learning Outcome 2 (LO2) includes four assessment standards; “Recalling meaningful information when needed”, “Categorizing information to reduce complexity and look for patterns”, “Interpreting information” and “Applying knowledge to problems that are not taught explicitly”. The last assessment standard is only applied for students in the senior phase. All observed science lessons included elements for “Recalling meaningful when needed”. For “Categorizing information to reduce complexity and look for patterns”, eleven lessons included activities related to categorizing. For “Interpreting information”, an activity in which students converted data into graph format was observed in one lesson. In four lessons, students interpreted the results of the experiments and related to the scientific concept supported by teachers. For “Applying knowledge to problems that are not taught explicitly”, one lesson included activities related to this standard.

Learning Outcome 3 (LO3) includes three assessment standards for the intermediate phase and two assessment standards for the senior phase. The assessment standards for the intermediate phase were “Understanding science and technology in the context of history and indigenous knowledge”, “Understanding the impact of science and technology on the environment and on people’s lives”, and “Recognizing bias in science and technology which impacts on people’s lives”. The assessment standards for the senior phase were “Understanding science as a human endeavor in cultural contexts” and “Understanding sustainable use of the Earth’s resources”. Out of six lessons of the intermediate phase, two lessons treated knowledge related to “Understanding the impact of science and technology on the environment and on people’s lives”. Out of twelve lessons of the senior phase, only one lesson treated knowledge related to “Understanding sustainable use of the Earth’s resources”. In these lessons, students were given knowledge related to LO3 by teachers when the lessons were concluded.

6. Contents of Discussions in Reflection Sessions

There were two types of reflection sessions; plenary-type reflection sessions and workshop-type reflection sessions. The plenary type of reflection sessions was based on the procedure which CIs and CLs learned in lesson study training in Japan. In the first round, the facilitator of the reflection

Table 2 Outline of observed science lessons as a study lesson in Mpumalanga

No.	Date	Content area	Grade	Number of group (number of students in each group)	Topic	Activities	Materials	Learning Outcomes related activities	Remarks
1	September 2009	E&C	G5	6(5-7)	Trasfer of sound	- Teacher asked to predict "Can sound travel through air?" - Students shared predictions -Teacher demonstrated experiment using improvised material - Students conducted experiments as teacher did - Students shared the findings - Teacher summarized lesson by asking questions.	Apparatus for experiments, large papar, worksheet	LO1:Planning investigation, conduct investigation, communicating findings LO2: Recalling information Core knowledge: sound trasfers energy through a gas	- A question for prediction required yes-no answers - Teacher showed all preocess of experiment and students just followed.
2	September 2009	M&M	G7	8(5-6)	Phases of matter	- One group conducted melting of ice -One group conducted boiling of water and condensation of water vapor -One group burned paper	Apparatus for experiments, worksheet	LO1: Conduct investigation, communicating findings LO2: Recalling information Core knowledge: Some changes to materials are temporary but others are permanent. Substances change when they receive or lose energy. (Intermediate phase)	- Students did not record their observation - Students had no chance to predict and share their findings
3	September 2009	M&M	G7	8(6-7)	Conductor and insulator	- Groups of students touch the wood, metal and plastic spoons in hot water - Groups of students shared findings	Apparatus for experiments, worksheet	LO1: Conduct investigation, communicating findings LO2: Recalling information, categorizing information Core knowledge: Materials are evaluated and classified by their properties; thermal conductivity or insulation. (Intermediate phase)	- Teacher explained concept very well and students just test the concept - Conditions of experiment was not controled
4	September 2009	M&M	G6	9(4-6)	Dissolving of substances in water	- Groups of students tested dissolving of fine and coarse grained salt in water - Groups of students tested dissolving fine grained salt in cold and hot water - Teacher summarized lesson	Apparatus for experiments, worksheet	LO1: Conduct investigation, communicating findings LO2: Recalling information, interpreting information Core knowledge: The dissolving substance in a solvent depends on variables which affect the rate of dissolving.	- Conditions of experiment was not controled
5	September 2009	E&C	G7	6(8-9)	Trasfer of heat	- Groups of stdudents put the plastic, wood and metal spoons attached pin with petroleum jerry into hot water. - Group presentaion of the results - Teacher asked students ""why did the pin fall down?"" - Teacher shown the examples in daily life.	Apparatus for experiments, worksheet	LO1: Conduct investigation, communicating findings LO2: Recalling information, categorizing information, interpreting information LO3: Impact on people's lives Core knowledge: Hot objects trasfer energy to colder objects, and conduction is one of three ways.	- Teacher had better to think students the reason that falling pin indicated the trasfer of heat
6	September 2009	L&L	G5	5(5)	Organisms' habitats	- Groups of students answered questions related habitats of the animal on the distributed worksheet by recalling information	Worksheet, flip charts	LO1: Communicating findings LO2: Recalling information Core knowledge: Organisms' habitats are the place where they feed, hide, produce young	- There were no resources which students refer and students just recalled informatios about animals
7	February 2011	M&M	G6	13(4-6)	Solution	- Groups of students put various materials into water and test their solubilty.	Apparatus for experiments, worksheet	LO1: Conduct investigation LO2: Recalling information, categorizing information Core knowledge: Materials are evaluated anc classified by their properties; solubility	- Teacher did not confirm how did students distinguish solution from mixture before and experiment
8	February 2011	E&C	G7	4(8-12)	Trasfer of heat	- Teacher heated a metal rod with pins attached by petroljerry to show conduction of heat - Groups of students heated and touched rods made of glass, metal and wood to test cunductivity - Students shared the results	Apparatus for experiments, worksheet, large paper	LO1: Conduct investigation, communicationg findings LO2: Recalling information, categorizing information Core knowledge: Hot objects trasfer energy to colder objects, and conduction is one of three ways. Classification of materials by their thermal conductivi(Intermediate phase)	- Core knowledge of senior phase was shown in demonstration and main activity was related to intermediate phase core knowledge - Teacher asked to predict but he did not wait the answer.
9	February 2011	M&M	G9	5(7-12)	Oxygen reacts with metals	- Groups of students observed magnesium reacted with oxygen and formed oxide.	Apparatus for experiments, worksheet, periodic table	LO1: Conduct investigation LO2: Recalling information Core knowledge: Oxygen has characteristic reaction with metals, forming oxide. Some metals react more readily with oxgen than other metals.	- Teacher asked students to conduct experiment before they know what they shuld observe

Table 2 (Continued)

No.	Date	Content area	Grade	Number of group (number of students in each group)	Topic	Activities	Materials	Learning Outcomes related activities	Remarks
10	February 2011	E&C	G7	6(5-6)	Trasfer of heat	- Groups of students observed convection of heat in water heated by spirit burner -Groups of students observed conduction of heat using metal rod with four pins attached with petroljerry -Groups of students shared findings	Apparatus for experiments, worksheet,	LO1: Conduct investigation, communicationg findings LO2: Recalling information, categorizing information Core knowledge: Hot objects trasfer energy to colder objects, and conduction and convection are two of three ways.	- Teacher asked students to conduct experiments before they know what they should observe
11	March 2011	E&B	G7	7(6-8)	Composition of atmosphere	-Students drew pie-chart to show the composition of atmosphere	Worksheet, poster	LO2: Recalling information, nterpreting information LO3: Sustainable use of the Earth's resources Core knowlegde: The atmosphere is a mixture of nitrogen and oxgen, and small quantities of other gasses	- Teacher and all students could not draw the pie-chart propery
12	September 2011	M&M	G6	6(5~10)	Electrical condctivity	- Groups of students predicted electrical conductivity of ten materials and shared - Groups of students tested electrical conductivity by apparatus made of small bulb, battery and conducting wire	Apparatus for experiments, worksheet	LO1:Planning investigation, conduct investigation, communicating findings LO2: Recalling information, categorizing information LO3: Impact on people's lives Core knowledge: Materials are evaluated and classified by their properties; electrical conductivity"	- Students conducted experiments according to one by one instructions - Teacher cocluded the lesson without using students' findings
13	September 2011	M&M	G9	6(6-8)	Acids and bases in household substances	- Groups of students predicts characteristics and acidic/basic with pre-knowlegde - Teacher demonstrated experiment in which change of color of litmus paper showed the materilas were acidic/basic.	Apparatus for experiments, worksheet, large paper	LO1:Planning investigation, conduct investigation, communicating findings LO2: Recalling information, categorizing information Core knowledge: Many household materials are acidic or basic. Indicators are substances that react with acids and soluble bases to produce products that have distinctive colors.	- Teacher asked students to predict color change of indicator which they did not know - Students did not record the results
14	September 2011	L&L	G7	14(4-5)	Clasification of plants	- Groups of students observed seeds, leaves and flowers - Groups of students classified pictures of plants and shared the findings	Apparatus for experiments, worksheet	LO1: Plannong investigations, conducting experiment, communicating findings LO2: Recalling information, categorizing information Core knowlegde: Classification is a mean to organize the great diversity of organisms and make them easier to study.	- Students just saw the samples and did not draw figures or texts to grasp characteristics
15	September 2011	E&B	G5	6(5)	Property of soil	-Ovservation of three types of soil and sharing -To predict and test water retention for three types of soil by measuring how much water pass through	Worksheet, appratus for experiments, large piece of paper	"LO1: Conducting experiment, communicating findings LO2: Recalling information, categorizing information, interpretation of data LO3: Impact on people's lives Core knowlegde: Property of soil (water retention)"	- Students presented their predictions but were not asked the reason
16	September 2011	M&M	G7	6(8-9)	Separation of mixtures	- Groups of students tried to separate various mixtures of different materials by hand picking, filtration, magnetism - Groups of studnets shared their results	Worksheet, appratus for experiments	LO1: Conducting experiment, communicating findings LO2: Recalling information, applying knowledge Core knowlegde: Differences in properties can be used to separate mixtures of different sunstances	- Teacher did not tell groups what they should do
17	September 2011	M&M	G9	3(6-7)	Electrical current through parallel connected resistors	-Teacher demonstrated experiment to measure the electric current in a palarell circuit and students recorded the results - Students interpreted the data according to worksheet	Worksheet, appratus for experiments	LO1: Conducting experiment LO2: Recalling knowledge, interpreting information Core knowlegde: Resistors can be selected or designed to control currents	- Students did not record their observation - Data teacher asked student to collect was not enough to construct knowledge
18	September 2011	E&B	G7	6(5-8)	Layered structure of the Earth	- Groups of students observed section of a model of earth made by teacher - Groups of students observed cut egg as a model of earth	Worksheet, appratus for model experiment	LO1: Conducting experiment LO2: Recalling information, categorizing information Core knowlegde: The planet earth has alayered structure with lithosphere, mantle and core	- Students seemed to be confused because model of earth tecaher prepared had four layers and egg had three layers

session asks good point of the study lesson to the presenter of the lesson. Then participants list good points of the lesson until these are exhausted. In the second round, the facilitator asks the presenter to give concrete suggestions for the improvement of the lesson, and participants are likewise asked to give suggestions concerning the lesson. Workshop-type reflection sessions were held from February 2011 by the author. Workshop-type reflection sessions are now very popular in school-based lesson study in Japan. In workshop-type reflection, all participants write their opinions on the labels which are distributed to them. Only one opinion should be written on one label. Two labels for good points and two labels for challenges and suggestions are distributed to the participants. The facilitator collects the labels and pastes the labels on the blackboard divided into good points and suggestions. The facilitator starts the discussions by reading aloud the contents of labels and categorizing the labels into various groups according to the perspectives of the lessons such as lesson structure, elements of lessons etc. The facilitator asks the writer to explain content of the label if clarifications are needed.

6.1 Contents of Discussions in Plenary-Type Reflection Sessions

Six plenary-type reflection sessions were held in September 2009. The speakers in the reflection sessions were presenters of the study lessons, some teachers, CIs and Officers from MDoE. Some teachers seemed to hesitate to express their opinions to others. Their passive attitudes toward the reflection sessions may be explained as follows. It might be first time for them to discuss the lesson which they observed and they were not familiar with discussion. They had to raise their hands to ask permission to speak and they might not dare to do so.

Their remarks in the reflection sessions were categorized into eight different points of view as follows; “Teacher”, “Pedagogy in general”, “Pedagogy for science education”, “Content of the lesson”, “Teaching/Leaning materials”, “Activities”, “Students in general” and “Students in science lesson”. Each category has sub-categories. “Amount of content knowledge of teacher” and “Level of the voice of teacher” were the main subcategories of “Teacher” category. The main sub-categories of “Pedagogy in general” were “Lesson planning”, “Learner-centered approach”, “Asking previous knowledge of students” and “To teach how to make presentation”. The main sub-categories of “Pedagogy for science education” were “Safety caution”, “Explanation of terms and concepts” and “Clarity of instruction for experiment or observation”. The main sub-category of “Content of the lesson” was “Appropriateness of terms”. The main sub-categories of “Teaching/Leaning materials” were “Improvisation” and “Quantity of materials”. The main sub-categories of “Students in general” were “Participation of students” and “Role of students in group”. The main sub-category of “Students in science lesson” was “Students Experiment/Observation by themselves”.

The mean of the total number of categories which appeared in reflection sessions was 12.33 (Table 3). The shares of good points and suggestions in all categories were 63.5% and 36.5% respectively. Dominant categories in the reflection sessions were the following: “Pedagogy in general” for good points (24.3%), “Pedagogy in general” for suggestions (16.2%), “Teaching/learning materials” (14.9%). The share of science education related categories was 47.3% of all categories (Table 4). Categories of remarks in reflection sessions were examined according to assessment standards of natural science (Table 4). The share of categories related to Learning Outcomes was 25.7% of all categories. The share of categories related to Learning Outcomes was 54.3% of categories related to science education. For LO1, remarks in reflection sessions were categorized into “Planning investigations”, “Conducting investigations and collecting data” and “Evaluating data and communicating findings”. For LO2, remarks in reflection sessions were categorized into “Recalling meaningful information”. There were no remarks categorized into LO3 and other assessment standards of LO1 and LO2. The dominant category within LO related remarks was “Conducting investigations and collecting data”, 57.9% of LO related categories.

Table 3 Contents of discussions in reflection sessions

	Plenary-type reflection session	Share(%)	Workshop-type reflection session	Share(%)
Good points				
Teacher	0.33	2.7	1.08	7.3
Pedagogy in general	3.00	24.3	3.25	22.0
Pedagogy for science education	1.00	8.1	0.75	5.1
Cotent of the lesson	0.33	2.7	0.17	1.1
Teaching/learning materials	1.83	14.9	1.25	8.5
Activities	0.00	0.0	0.17	1.1
Students in general	1.00	8.1	1.00	6.8
Students in science lesson	0.33	2.7	0.50	3.4
		63.5		55.4
Suggestions				
Teacher	0.00	0.0	0.08	0.6
Pedagogy in general	2.00	16.2	2.83	19.2
Pedagogy for science education	1.17	9.5	1.50	10.2
Cotent of the lesson	0.17	1.4	0.17	1.1
Teaching/learning materials	0.33	2.7	0.42	2.8
Activities	0.17	1.4	0.83	5.6
Students in general	0.17	1.4	0.17	1.1
Students in science lesson	0.50	4.1	0.58	4.0
		36.5		44.6
Total number of categories in one lesson (mean)	12.33		14.75	

Table 4 Contents of discussions in reflection sessions categorized into general and science education

	Plenary-type reflection session	Share(%)	Workshop-type reflection session	Share(%)
Good points				
Categories related to science edcuation	3.50	28.4	2.83	19.2
Categories in general	4.33	35.1	5.33	36.2
Suggestions				
Categories related to science edcuation	2.33	18.9	3.50	23.7
Categories in general	2.17	17.6	3.08	20.9
Total				
Categories related to science edcuation	5.83	47.3	6.33	42.9
Categories in general	6.50	52.7	8.42	57.1
Total number of categories in one lesson (mean)	12.33		14.75	

Table 5 Contents of discussions in reflection sessions categorized from the view point of Learning Outcomes

	Plenary-type reflection sessron	Share (%)	Workshop type reflection sesslon	Share (%)
LO1 Pianning investigations	0.33	10.5	1.42	35.4
LO1 Conductiong investigations and collecting data	1.83	57.9	1.08	27.1
LO1 Evaluating data and communicating findings	0.50	15.8	0.75	18.8
L02 Recalling meatingfu1 information when needed	0.50	15.8	0.67	16.7
L02 Interereting information	0.00	0.00	0.08	2.1
Total	3.17		4.00	
Ratio of Learning Outcome related categories and scicnce education related categories		54.3		63.2
Ratio of Learning Outcome related categories and tota1 categories		25.7		27.1

One of the identified challenges of reflection sessions in lesson study is the remarks which focused on the pedagogy in general. The remarks relating to teaching/learning materials focused on availability of the materials and improvisation. The remarks relating to students focused on participation, group work and students conducting experiments by themselves. Participants seemed to check the presence of something in the lesson, such as questions related to pre-knowledge, safety caution, availability of materials, experiments by students and group work. Categorization of the remarks for LOs indicates that the participants focused on the conducting experiments (Table 5). Participants did not focus on the evaluation and interpretation of data, which are very important elements in science education. The comments on the lessons seem to be superficial and mainly contribute to improve the pedagogical side of lesson delivery. There are very weak links between activities and the scientific concepts or knowledge which students should learn. Participants did not focus on the processes by which students learn.

6.2 Contents of Discussions in Workshop-Type Reflection Sessions

To cope with the passive participation of some teachers in plenary-type reflection sessions and to improve the contents of reflection session, workshop-type reflection sessions were held by the author from February 2011. Twelve reflection sessions were observed in lesson study workshops in primary and secondary schools in February, March and September 2011. In workshop-type reflection sessions, all participants could share their opinions by writing them on the labels. Also they could find very easily which point of view they applied for observations of and suggestions to colleagues because all labels were pasted on the board. They thought it is very good for saving time during discussion. In workshop-type reflection sessions, the facilitators were expected to develop discussions utilizing labels written by participants, but facilitators just summarized the contents of labels in most cases.

Their remarks from the reflection sessions were categorized into eight different points of view (Table 3). “Amount of content knowledge of teacher” and “Level of the voice of teacher” were the main subcategories of the “Teacher” category. The main sub-categories of “Pedagogy in general” were “Lesson planning”, “Time management”, “Asking previous knowledge of students”, “Q&A method”, “Group work” and “Size of group”. The main sub-categories of “Pedagogy for science education” were “Explanation of terms and concepts” and “To teach what should be observed”. The main subcategory of “Teaching/Leaning materials” was “Quantity of materials”. The main sub-category of “Students in general” was “Participation of students”. There were no main sub-categories for “Content of the lesson”, “Activities”, “Students in general” and “Students in science lesson”.

Mean of total number of categories in workshop-type reflection and the share of suggestions in all categories increased from those of plenary-type reflection. Those changes are explained by the change of the procedure of the reflection session. Mean of total number of categories which were appeared in reflection sessions was 14.75 (Table 3). The share of suggestions in all categories was 44.6%. In workshop-type reflection, every participant was asked to write his or her opinions on the labels. This type of participation may encourage remarks from various points of view to emerge. Two labels were distributed to the each participant for both good points and suggestions; therefore, half of the remarks should have been suggestions ideally.

Categories of remarks in reflection sessions were examined according to assessment standards of natural science (Table 5). The share of categories related to Learning Outcomes is 27.1% of all categories. The share of categories related to Learning Outcomes is 63.2% of science education categories. For LO1, remarks in reflection sessions were categorized into “Planning investigations”, “Conducting investigations and collecting data” and “Evaluating data and communicating findings”. For LO2, remarks in reflection sessions were categorized into “Recalling meaningful information” and “Interpreting information. There were no remarks categorized into LO3 and other assessment standards of LO1 and LO2. Dominant categories within LO related remarks were “Planning investigations” (35.4%) and “Conducting investigations and collecting data” (27.1%).

7. Discussion

7.1 Current Status of Natural Science Lessons Based on the New Curriculum

“Model lessons” presented as a study-lesson in lesson study workshops indicated that science teachers of Mpumalanga have enough potential and eagerness to implement science lessons according to the new science curriculum. All study lessons were activity based lessons. Teachers prepared apparatus and materials for experiments, worksheets which students followed, the large pieces of paper on which students wrote their opinions, visual aids such as cards, and posters. To achieve outcomes stated in RNCS, teachers prepared activities for LO2 in all observed lessons and for LO1 in most of the lessons. These observations are very different from those of previous studies. Stoffels (2005) conducted case studies of two Grade 9 science teachers in two secondary schools of Gauteng and reported that two science teachers heavily depended on the commercially prepared outcome based textbooks. In the study lesson observed, the teachers did not use commercial textbooks. Bantwini (2010) reported that 95% of science teachers in primary schools of Eastern Cape did not implement RNCS in 2006 and the remaining 5% mentioned that they introduced group work and allowed students to take control of their learning.

Rogan and Aldous (2005) applied a theoretical framework developed by Rogan and Grayson (2003) and described mathematics and science lessons of Grade 8 and Grade 9 teachers in Mpumalanga in 2002. The observed science lessons were examined based on “Profile of Implementation” in the same theoretical framework that Rogan and Aldous (2005) applied. “Profile of Implementation” is composed of four sub constructs; “classroom interaction”, “science practical work”, “science in society” and “assessment”. In this study, only three sub constructs were examined and the results were compared with the results of Rogan and Aldous (2005). The mean ratings of observed study lessons for “classroom interaction”, “science practical work”, “science in society” were 1.78, 2.06, and 0.22, respectively (Table 6). The mean ratings presented by Rogan and Aldous (2005) were 1.10, 0.75, and 0.35, respectively. The ratings for “classroom interaction” and “science practical work” are improved. The study lessons observed in this study included more elements of new curriculum than those of 2002.

Some outcomes of the new curriculum were not observed in study lessons. Although most of the study lessons included science practical, this practical work did not seem to help students construct scientific knowledge and concepts. Teachers did not ask students to use higher order thinking skills, such as “raising questions about a situation”, “predicting” “interpreting information”, in the lessons. The practical work was explained to students before they prepared to observe the phenomena and to connect findings to the science concepts which they should learn. Students presented their findings but teachers did not utilize these finding and conclude the lessons with explanation of scientific concept with prepared summary of the explanations of scientific concepts.

Table 6 Levels for profile of implementation of study lessons based on Rogan and Grayson (2003)

Levels for Profile of implementation			
No	Classroom interaction	Science practical works	Science in society
1	2	2	0
2	1	1	0
3	2	2	0
4	2	3	0
5	2	3	1
6	1	1	0
7	2	2	0
8	2	2	0
9	2	2	0
10	2	3	0
11	1	2	1
12	2	2	1
13	2	2	0
14	2	2	0
15	2	3	1
16	2	2	0
17	1	2	0
18	2	1	0
Mean	1.78	2.06	0.22

Some challenges were observed in students who were expected to express their opinions in their own words and to record their finding in various ways. In the study lessons, although students had chances to express their predictions and findings, they could only express their opinions in very few words and could not explain their ideas in detail. Also most of the expression of students was oral or written text and they did not use drawings. Also they were not good at presenting their ideas to others. When they used large-sized of paper for a presentation, they read the text without showing the paper to their colleagues. These challenges may be explained by the low level of their reading skill (seventh place out of 9 provinces in South Africa based on the result of SAQMEQ III in Hungi et al., 2010). Students might not have a chance to express their opinion in usual lessons.

7.2 Science Teachers' Beliefs in Science Lessons

Observed study lessons can be considered as model lessons in which teachers' beliefs in science lessons were reflected. These beliefs were also stated as remarks in the reflection sessions and reinforced repeatedly. Teachers seemed to think conditions of a good science lesson were as follows; “lesson should be well prepared and followed the lesson plan”, “pre knowledge should be asked”, “definition and explanation of terms and concepts should be presented”, “safety precaution should be presented”, “experiments should be conducted by students themselves”, “group work should be included” and “lesson should be concluded by teachers”. They think a good science teacher is someone who understands the content well, has an audible voice, manages time, applies Q&A methods, organizes an appropriate size of a group, and asks students to work in groups. They think good students are those who predict, participate, play roles in their group, do practical work and report their findings according to instructions of the teacher. They think good learning materials are those that are improvised, and are of sufficient amounts for each group.

These science teachers’ beliefs seem to be lacking in the perspective of how students construct scientific concepts and knowledge through practical work. The science teachers strongly believe that students can easily predict results, observe the phenomena, record the result and connect the results with scientific concepts if the teachers just provide students “cook-book type” practical works (Rogan, 2007). The science teachers did not ask students how the concept will be tested in practical work, what kind of phenomena will be observed, or how the results are interpreted. As Saito et al. (2006) indicated, these teachers are not interested in the learning process of students.

Although the science teachers introduced practical work, their original teaching style, in which the teachers provide knowledge to students, seems to remain unchanged. The science teachers explained and defined the scientific concepts using scientific terms, which should be found in the practical work, before the practical work started. The purpose of the practical work is just to reconfirm the scientific concepts which the science teacher provides and not to construct scientific concept based on the findings. So teachers did not seem to focus on the results of the practical work but focused on the prepared conclusions. Science teachers seem to think that the purpose of science education is to teach students the scientific concepts by the means of established practical work. They do not think that the science concepts were derived from the results of experiments or observations.

The superficial interpretation of science curriculum by science teachers in Mpumalanga can be explained by cultural aspects of the lessons. As Stigler and Hiebert (1999) indicted, teaching is cultural practice and a very stable system which is formed by informal participation over a long time. It is not so easy to change the stable teaching style. When teachers are requested to change their style, they do not change the whole system but only pick up superficial characteristics and adopt them into previous teaching styles.

7.3 Possibility of Lesson Study as Continuous Professional Development in Mpumalanga

Science teachers of Mpumalanga who participated in lesson study were very positive to conduct lesson study. They thought that lesson study can contribute to the professional development of teachers. They considered that teachers could learn from each other through the planning process of lesson study about content knowledge, teaching methodology and assessment strategy. Study lessons presented by one of the colleagues were considered as model lessons through which teachers could share real images of the intended curriculum. In reflection sessions after a study lesson, teachers could discuss the lesson and give suggestions to improve their practices in a calm and warm atmosphere.

Although MDoE supported dissemination of lesson study by organizing lesson study dissemination workshops in four regions and by utilizing NUE follow up visits for lesson study workshops in primary and secondary schools, the actual implementation of continuous lesson study in clusters or schools was still limited. As Ono and Ferreira (2010) indicated, to institutionalize lesson study in their continuous professional teacher development, MDoE should make the effort to involve not only teachers and CIs but also principals and local educational administrators.

Contents of reflection sessions indicated that the current discussion could contribute to the improvement of the delivery side of the lessons. Their suggestions for improvement were concentrated in the categories of pedagogy in general and pedagogy in science education (Table 2). Although the workshop-type reflection procedure was effective to improve equal participation of observers, it was still difficult for the participants to discuss how to improve learners' scientific understanding. Saito et al. (2006) pointed out the tendency of Indonesian mathematics and science teachers who did not focus on the learning process of students. Science teachers in Mpumalanga also did not discuss the learning process.

O' Sullivan (2004) indicated the usefulness of the adaptive approach which examines the reality of the school and experiments with strategy that focuses on student learning achievement within limitations. To know how a lesson can be improved in a given context, Rogan and Aldous (2005) and Rogan (2007) used the concept of "Zone of Feasible Innovation (ZFI)" which was proposed by Rogan and Grayson (2003). ZFI seeks to gauge the appropriateness of an innovative practice in a given situation to identify those practices that can be successfully implemented at a given time. To seek ZFI for current science lessons, reflection sessions may be useful.

In the case of Indonesia, university faculty members contributed to improve changes of the academic base and the introduction of experiments (Saito et al., 2006). For science teachers of Mpumalanga, it is not easy to invite a university faculty member as a resource person in reflection sessions because there are no higher educational institutes in Mpumalanga. Although CIs should be resource persons who contribute to discussions focused on students' learning process and some of them played this role, most of them still had difficulties to observe lessons from a student's perspective. Of course the change of teaching culture is not easy; therefore continuous efforts are needed to observe lessons based on the students learning process. Reflection on the reflection sessions should help them to observe lessons on the students learning process.

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