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Continually Expanding Content Representations: A Case Study of a Junior High School Biology Teacher

SHEAU-WEN LIN

Department of Mathematics and Science Education
National Pingtung Teachers College
Pingtung, Taiwan, R.O.C.

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ABSTRACT

The purpose of this study was to explore how an experienced biology teacher continually expanded representations in her teaching career. Participant observation, interviews and various related documents were used to collect data. The findings were presented in terms of five assertions: (1) The evaluation of representations made the teacher feel the need for change. (2) The teacher arranged representations in an expanding sequence. (3) The teacher searched for data to form alternative representations. (4) New representations resulted from modification, specification, combination, or invention. (5) Representations were modified through pretests and classroom teaching. The incompleteness of representations made the content transformation act a dilemma. As Lucy managed dilemmas, she reflected on her representations and continually expanded the representations. This process was based on her extensive knowledge, and this knowledge was developed during the process. The implication of this study is that science teachers can reflect on their representations to promote professional growth.

Key Words: content representation, professional knowledge growth, interpretive research

I. Introduction

The entrance examination has become a major factor influencing the teaching practices and quality of learning in junior high schools in Taiwan. In order to help students get high scores on the entrance examination, teachers often put emphasis on repeated exercises that aid the retention of facts. The content of the curriculum is usually based on textbooks and the questions asked on examinations. Students' learning life is full of examinations and memorization of facts from textbooks.

Increasingly, people have begun to reflect on the educational quality of primary and secondary schools and calls for educational reform have been proposed. They emphasize the importance of learning equality for all children and are asking for a higher quality learning environment. Despite this situtation, why do teachers still slide into traditional routines and repeat the things they have done before? Can teachers develop critical ways of understanding their teaching contexts and alter their teaching practices to enhance student learning?

Studies have proposed that content transformation is the central intellectual work of teaching (Shulman, 1986, 1987). To foster understanding of science, successful teachers cannot only have an undrestanding of a concept, principle, or theory of science. They must develop the ability to represent the content in different ways to communicate knowledge to their students. Through a lens of representation, this study explored how an exemplary junior high school biology teacher, who had succeeded in remaining enthusiastic over the course of a 13-year career, continually expanded her repertoire of representations to help her students learn biology. Representations are defined in this article as ways of representing the subject to make it comprehensible to students in real teaching contexts.

Examining teaching in terms of representations instead of methods or strategies is intended to focus attention not just on activities of teachers and students in a classroom but on the relationship between activities and the science knowledge taught. The concept

of representations illuminates the wholeness of teaching content and strategies (McDiarmid, Ball, & Anderson, 1989), which both influence student learning. The notion of representations also explains subject-specific properties of teaching (Shulman, 1986). Teachers need to consider different issues in different subject mater when they transform subject matter and select and evaluate representations. Using representations appropriately demands specific knowledge (McDiarmid *et al.*, 1989).

The results can contribute to a better understanding of the nature of life-long learning in science teaching, especially for science teacher educators and science teachers who believe that continual learning from teaching practices plays an important role in professional growth.

II. Review of Literature

Within the learning-to-teach literature, researchers examine the developmental concerns of student teachers (Fuller, 1969), developmental stages (Berliner, 1988; Kagan, 1992), their roles and beliefs (Brickhouse, 1990; Duffee & Aikenhead, 1992; Munby, 1984, 1986; Tobin, 1990a, 1990b) and their knowledge (Geddis, Onslow, Beynon, & Oesch, 1993; Lederman, Gess-Newsome, & Lantz, 1994; Shulman, 1986, 1987; Wilson, Shulman, & Richert, 1987). Researchers have also tried to understand the nature of beginning teachers' critical transition from college students to school teachers and support beginning teachers' teaching needs.

Most of the above literature puts emphasis on beginning teachers' professional growth. However, learning to teach is a lifelong process and as one teaches, one learns (Feiman-Nemser, 1983). Passing the survival stage does not guarantee that teachers will successfully continue to grow. The stage theories do not imply that earlier stages lead naturally to later stages (Grossman, 1992). In a review article Britzman (1986) described the way in which teachers' personal histories interacted with common myths of their culture to maintain current teaching practices. She concluded that without a critical perspective, student teachers would lose their intention to enhance the potential of students and slide into a cycle of repetition of other teachers' teaching. Feiman-Nemser & Buchmann (1989) conducted interviews and classroom observations with six teacher candidates throughout two years. They reported that teachers were satisfied with their teaching and became less likely to criticize the prevailing norms after mastering the socially patterned school routines. Some teachers in this study paid attention to management problems, but didn't necessarily learn how to teach.

Science education researchers have indicated that several constraints shape science teachers' development or prevent them from changing in their teaching environment (Abell & Roth, 1992; Brickhouse, 1993; Lantz & Kass, 1987; Loughran, 1994; Tobin, 1990a, 1990b; Tobin, Briscoe & Holman, 1990; Tobin & Gallagher, 1987; Wallace & Louden, 1992; Wood, 1988). These constraints included institutional and social expectations, accountability via test scores, curriculum, equipment, support, time, knowledge, experience, and beliefs. These researchers also suggested that critical thinking or reflection is an important first step if teachers are to change and improve their teaching. Sharon, an elementary teacher of mathematics and science, was a participant in the study of Tobin *et al.* (1990). Through reflection on her interactions with colleagues and students, Sharon perceived a problem with the curriculum. She confronted constraints and sought the support she needed. Sharon became an agent for change for herself and for the colleagues and children with whom she worked.

Researchers have acknowledged the importance of content transformation in teaching. What is the theoretical framework of the process of transformations? In "Knowledge Growth in a Profession Project," Shulman and his associates (e.g., Carlsen, 1991; Hashweh, 1987; Shulman, 1986, 1987) focused on how the subject matter knowledge of novice teachers grew and changed over time. As they observed and conversed with teacher collaborators, they found that novice teachers struggled to develop many different ways to explain the content of their disciplines in order to help their students learn (Shulman, 1986, 1987). They constructed a theoretical framework for understanding the reasoning process of transformations. To accomplish transformations, teachers draw on pedagogical content knowledge. Pedagogical content knowledge is "a blend of pedagogy and content which included an understanding of how the topics in instruction were related and how they were most effectively organized and presented in the classroom context" (Shulman, 1987). Pedagogical content knowledge also includes knowledge of alternative representations of a particular subject and knowledge of understanding and misconceptions of a subject. This knowledge is developed in a cyclic process in which teachers comprehend, transfer, instruct, evaluate, reflect, gain new comprehension, and transfer again. The transformation process involves four subprocesses: interpretation, representation, adaptation, and tailoring to student characteristics (Shulman, 1986, 1987).

In science teaching a growing body of recent research has utilized Shulman's concept of pedagogical content knowledge. Geddis *et al.* (1993), for example, described two student teachers' attempts at teaching the subject of chemical isotopes. The researchers collected data by interviews and classroom observations. In the course of analysis, examples of four distinct categories of pedagogical content knowledge were articulated. Knowledge of learners' prior knowledge, effective teaching strategies, alternative representations, and curricular saliency were all important components of the pedagogical content knowledge that beginning chemistry teachers needed to acquire. The researchers claimed that the components of pedagogical content knowledge played important roles in the task of effective transformation.

Most of these studies beginning with Shulman's suggested that pedagogical content knowledge plays important roles in transformations of subject matter. Researchers have tried to articulate the concept of pedagogical content knowledge by exploring knowledge growth in student teachers. They paid little attention to the dynamic aspect of pedagogical content knowledge and to continual growth in experienced teachers. Interviews and observations were major methods of collecting data. However, many of the studies were conducted in laboratory settings (Hasweh, 1987; Marks, 1990). Transformations are complicated in real teaching contexts. There are many factors that influence transformations of subject matter. It seems that a true picture of a teacher's expanding process of representations can only be derived in the context of a naturally occurring classroom setting.

This study collected data through extensive classroom observations, teacher interviews, and review of documents. It was sought to explore the process through which an experienced biology teacher continually expanded her representations and promoted growth in real teaching contexts. This process was not the trial-and-error approach that beginning teachers adopted. The teacher's goal of expansion was not a struggle to survive, but to renew and search for the most effective way to attain worthwhile goals.

III. Method

1. Selection of Teacher

The teacher in this case study was selected from a list of candidates containing exemplary biology teachers nominated by science education experts and scholars. An observation of potential participants' classroom teaching was also conducted to select a teacher who displayed expert characteristics in biology teaching and an expansion process of content representations. "Criteria of Excellence: Biology Teachers of Junior High School" (see Lin, 1994) describes expert characteristics in biology teaching as an accredited subject. The teacher and the school administrators were asked to cooperate. Through this procedure the teacher, Lucy, was selected.

2. Participant and Context

Lucy, a female teacher, had been a biology teacher for 13 years. She had won many awards. Some examples were the Taipei Municipal Annual Outstanding Teachers' Award, Award for Outstanding Achievemnt in the Taipei Municipal Science Fair, and Award for Outstanding Achievement in the Tiapie Municipal Teaching Aids Presentation.

Lucy worked in a school located in Taipei City. It was a co-educational public school where most of the students' families were of a working-class background with middle socioeconomic status. There were five biology teachers and 21 seventh grade classes in the school. Thirty-eight students, 18 boys and 20 girls, of mixed abilities were in the participating biology class.

3. Data Collection

Data was collected by means of observation, teacher interviews, and review of documents. Observations were made during twenty-eight 50 min lessons of the participating class, which were held continuously from March to June of 1992. The teacher interviews regarding content representations were conducted before and after each individual observation. An occasional lunch or tea time was arranged so that Lucy could be interviewed in a more casual setting. All observations and teacher interviews were video-recorded or tape-recorded. Related documents, including the teacher's lesson plans, notes, transparencies, work sheets, maps, charts, pictures, and tests, were preserved with photocopies or photographs.

4. Data Analysis

The data base consisted of field notes and transcriptions from observations, interviews, and related documents. Excerpts were taken from the field notes and transcriptions to describe teaching practices and tentative assertions concerning the practices. The excerpts were discussed with Lucy regularly throughout the study to confirm the significance of her be-

havior, and Lucy was also asked to comment on any ideas that she thought to be misrepresented or incomplete. Then, all the excerpts were coded and classified. Major categories included forms of content representations, processes of expanding representations, and teacher knowledge. Within each category were many subcategories, in the form of content representations such as metaphor, discussion, explanation, hands-on activity ... etc. All the excerpts were examined for trends and frequency. At this time tentative hypotheses about the processes of expanding content representations were formed. Then the specific trends were explored and more concrete hypotheses were formulated and tested with subsequent coded data from different data gathering methods. Contradictory data was sought to revise the hypotheses. Reliability check for coding were conducted with other researchers. (For more information on the data analysis, see Lin, 1994.)

IV. Findings

The findings of this case study are presented below in five assertions.

1. Assertion 1. Evaluation of Representations Caused Lucy to Feel Dissatisfied and Think There Was a Need for Change.

Lucy constantly changed her representations for the same concepts throughout her teaching career. She explained the used representations during interviews. Why did she change them? Lucy described her motivation to change her representation of "relationship between genes and traits" as follows:

> I had used different color glasses to interpret the relationship between genes and traits for many years. One day I stood in the back of the classroom, and I saw that the color of two overlapping red glasses was deeper than the one made by a transparent one and a red one. I was shocked by this phenomena. It might mislead students into thinking that the traits of homogeneous and heterogeneous combinations were different. I decided to correct this immediately.

If Lucy did not know the disadvantages of her representations, she would not feel the need to change them. There was not a repertoire of representations.

What was a "good" representation? For Lucy all representations had to be feasible in the teaching context. A representation also had to provide authentic information and be helpful to student learning. Lucy tried her best to transfer content but in practice circumstances were too complex to achieve all criteria simultaneously. Scientific information or scientists' explanations were always too technical for her students to comprehend. Though stimulating students' learning interest and making learning easier, transformations could not avoid distorting the meaning of the scientists' knowledge. For example, Lucy sometimes gave explanations in terms of purposes and intention (e.g., the male peacock blows its tail open to impress and attract the female) to help students learn. She said, "These anthropomorphic explanations may mislead student learning. Some students will think that animals, like human beings, have intentions."

Reflection on representations made Lucy see the characteristics of her teaching. Lucy knew that different representations could present different facets and dimensions of science. She said that some representations were closer to scientists' knowledge and some were easier to learn. She also mentioned that different representations could attract students' attention and meet individual needs. Lucy stated, "Every representation has its own advantages and limitations. None of them are perfect." This incompleteness of representations made Lucy feel they were unsatisfactory and there was a need to create other representations.

2. Assertion 2. Lucy Arranged Representations in an Expanding Sequence.

Every representation had its own advantages and limitations. It seemed that there was no representation which could represent all the meanings that Lucy wanted to present. Which one would Lucy choose to present? This was a dilemma. Presenting multiple representations for one concept was the strategy that Lucy selected to deal with this dilemma. Lucy said,

> I try to transform the content into different forms just like a cook who use the same meat or vegetables to prepare many different dishes. My students can select helpful forms to aid their understanding just as customers choose their favorite dishes to eat. No matter which one or ones they choose, they all learn the concept.

However, the expanding process was time consuming. Lucy could not transfer all concepts into multiple forms at the same time. Therefore she arranged them in a sequence to form alternative representations that would help students learn.

Lucy gave priority to forming multiple representations for difficult concepts. She noted students' common difficulties in learning biology. Most of these

concepts were within genetics, cell biology, and evolution. The common characteristics of these difficult concepts were complexity, having too many terms, being abstract, and not being observable with the naked eye.

About the unit of "genetics" Lucy said,

> Genetics is one of the difficult topics for the students. Students need the concepts of mitosis, meiosis, chromosomes, genes, sexual reproduction, asexual reproduction, genotypes, phenotypes, probability, ... etc. Students seldom have had a chance to observe these phenomenona before. These concepts are all difficult to learn. In particular, most of my students do not develop the ability to manipulate problems of probability.

As a consequence, it was a priority that difficult concepts be presented in different ways. For example, when teaching "mitosis", Lucy explained six representations. They were teacher explanation of the rules of mitosis, hands-on activity with mitosis cards, illustration of onion mitosis, illustration of fish mitosis, reading paper, and discussion. Lucy used about 70 pictures in the above teaching activities. She emphasized visual learning and hands-on activity in this case.

3. Assertion 3. Lucy Searched for Data to Form Alternative Representations.

Lucy required a body of knowledge that would contribute to her expanding collection of representations. Examples were knowledge of subject matter, students and learning, curriculum, teaching media, alternative representations, and context. She obtained this kind of knowledge from her personal learning experiences, teaching experiences, textbooks, other teachers, volunteer worker training, in-service training, and students' responses.

Subject matter knowledge was the content of representations. Lucy had received a bachelor degree in biology. She had also earned some master level credits in biology. Lucy already had extensive knowledge of biology. Most of the subject matter knowledge cam from her personal learning experiences. However, Lucy did not think that she had enough subject matter knowledge for teaching secondary school biology. She said, "Because of the diversity of biology, I cannot answer all questions students ask. I need to check it out in books." She told stories of biologists, for example Charles Darwin, Louis Pasteur, and Gregor Mendel. Lucy emphasized environmental issues in her biology class. She showed an environmental room filled with ten environmental problems occurred at Taiwan. This kind of knowledge did not come from her formal education but rather from books, journals, newspapers, volunteer worker training and in-service training. Lucy's subject matter knowledge, especially about science-technology-social issues, everyday life, and stories of biologists, was developed through the process of expansion.

Lucy needed knowledge about students and learning to communicate effectively. Lucy was concerned about what students knew about science knowledge, reasoning skills, and life experiences. When teaching "genetics", Lucy reviewed related topics in elementary school to find out what her students had learned. She asked a mathematics teacher about what her students had learned about probability. She also interviewed some students about the concepts of genetics. When these were ascertained, she designed activities for students in order to relate the new content to the old.

Lucy required knowledge concerning intended objectives, activities and textbook problems. She selected the proper content, put it in sequential order, linked concepts from different topics or lessons, and manipulated the pace. Most of this kind of knowledge came from her teaching experience, textbooks, and teacher's manuals.

Knowledge of contexts made Lucy adjust her ideals to the situation in the real practice environment. Lucy was familiar with the expectations held by society, the school, parents, and students after thirteen years of teaching. For example, the expectation of high achievement in examinations influenced her instructional emphasis and test content and made her increase test frequency. She knew the hardware and software in school and out. This had an impact on Lucy's decisions to use materials and media.

Knowledge of alternative representations allowed Lucy to conduct lively transformations. Lucy actively attended teaching conferences, in-service training, and volunteer worker training to get new ideas. She also discussed her teaching with her colleagues and teacher friends and thereby change her representations.

Lucy knew who and where would provide resources for teaching, and she would learn new methods and knowledge for improving her instruction when she felt the need. University libraries, science museums, educational data centers, botanical gardens, zoos, and national gardens were the places where she or her students usually visited to get information. Lucy also built good relationships with university professors, consultants of teachers' in-service training centers, and colleagues who could provide assistance and suggest alternatives to help solve teaching problems.

4. Assertion 4. New Representations Resulted from Modeification, Specification, Combination, or Invention.

If Lucy felt the need to change her representations, she tried to modify her representations for different students and teaching conditions. There were two kinds of modifications: inter-form modifications and intra-form modifications. The same content was transferred to different forms in the inter-form modification. For example, because of difficulty in handling students' responses, Lucy changed an illustration of "flowers" with the aid of slides to a student discussion with the aid of pictures. Lucy would only add, delete, or replace content and not change the form in intra-form modification. Giving students a familiar frog instead of an unusual salamander as an example of the amphibians was a case of intra-form modification. Modification seemed to be the most economical way to increase the effectiveness of representations.

Besides modification, Lucy also tried to create new representations. A new one could result from a specification, combination, or invention.

A specification was when Lucy borrowed the form of an existing representation from instruction in other subjects. Then she transformed a biology concept into the same form to generate a new representation. For example, a form Lucy used to help her students construct the concept of "classification of living things" came from a professor's representation for "shape". Lucy said,

> I taught the "classification of living things" according the content in the textbook for many years. I pointed out characteristics and names of animals and plants for each kind. Students were always confused by the names and characteristics of so many living things. There were communication problems between the teacher and students and between students and students. What students needed to do was to memorize ... I remembered a lively professor who showed us many different shapes but only answered yes or no questions. We all learned the classification scheme, characteristics and names of the shapes. Why shouldn't I use this form to teach "classification of living things"? I prepared pictures of different living things and showed them in my classification class. I asked students to raise questions that could be answered by yes or no to help them construct the classification scheme.

Lucy would combine representations to generate a new one. In the "mitosis" unit, Lucy combined a teacher demonstration of a model of mitosis with a student discussion on the characteristics of mitosis to form a student manipulation of pictures of mitosis. Combination always occurred in the condition that Lucy taught the same or related concepts.

Lucy also invented new representations. Lucy described the development of her representation of the "relationship between genes and traits" as the following:

> After deciding to change the representation of "relationship between genes and traits", I thought it over all day, every day, even while walking and during daily activities. One day an idea flashed into my mind. 'Ah ha, I got it' I said.

The expanding process took time. Sometimes, Lucy did not have any new ideas and her thoughts stayed in a latent stage. She did not like her strategy of repeated exercises to help students to learn the concept of "probability in genetics", but she did not know of any better strategy. Therefore, she concluded that repeated exercises were her best choice and presented them in her teaching. This did not mean that Lucy gave up. She worked hard to struggle with it.

5. Assertion 5. Representations Were Modified Through Pretests and Real Teaching Practices.

To make sure of the feasibility of new representations, Lucy would ask some students to do the tasks in a simulated teaching environment before using them. She observed students' responses and asked questions about new representations. Then she tried to change them. As an example, Lucy asked five students to do a worksheet on "asexual and sexual reproduction of plants" while out of class. She collected information about its readability and how much time was needed. According to students' reactions, she modified some items on the worksheet.

All the above actions were still during the planning stage. Many other factors could affect the success of a representation in a real classroom. Representations must be tested by direct teaching.

Teaching behavior was a focus that Lucy evaluated when she presented a new representation in the class. Lucy said,

> Whenever presenting the new materials or activities, I always paid attention to myself. During the class I asked myself, "What will I do next? Is the explanation clear enough?" I was busy with looking for pictures or specimens that I wanted to illustrate. I spent much time on managing the class. After teaching the same topic for the second or third time, I would have enough time to be attentive to student learning behavior.

After maintaining a fluid teaching flow, Lucy turned her attention to students' responses. Lucy analyzed test results, homework, and worksheets, kept an eye on student behavior, and conducted student interviews to collect learning information. She wanted to make sure that the representation could help students understand.

Lucy reviewed her teaching behavior, the teaching context, students' behavior, classroom management, and time arrangement. Depending on her memory and feelings about classroom events, she analyzed the events and tried to find factors which influenced the success of the representations. Later she reconstructed them for future instructional action. These activities happened both during class and afterwards. While discussing "the results of Hydra's asexual and sexual reproduction", there was no student response on this topic. Then Lucy showed another four different representations to help them participate in the discussion. About this event Lucy said,

> I saw dull expressions on the faces of my students and I knew I was in trouble. I guessed that they were too tired to keep their attention on my teaching after a whole morning of classes. I repeated the same explanation again. But they still did not respond. I decided to draw a picture and gave an example to help the students understand. Then I asked them to pretend that they were the Hydra family, to state their position, and to explain why they hold this position. This evoked a favorable response.

This was an example of Lucy's instructional action which resulted directly from her reflection during teaching.

Lucy's colleagues also participated in the evaluation of her representations. She always introduced and discussed new representations with her colleagues. They would give her feedback, such as if they liked it or disliked it and the reasons why.

V. Discussion

Throughout the cycle of teaching and reflection on representations, Lucy expanded her repertoire of instructional representations. This was a continuous process of learning to teach.

Coming from a family of teachers, Lucy looked forward to being a teacher and considered being a teacher her number one choice. For her, teaching was an important thing which would influence thousands of students. She thought that teachers played a key role in learning and could make a different world for students. She had high expectation of herself. She believed that a good teacher must be a learner of how to teach, and no man was born a successful teacher. Lucy had rich resources for learning to teach. Personal learning, teaching experience, textbooks, other teachers, volunteer training, in-service training, university professors, library services, consultants at teachers' in-service training centers, museums, parks, and students' responses were all probable sources of her knowledge base. Her belief in learning how to teach and rich resources for learning how to teach helped her knowledge develop continually.

For Lucy, an ideal representation was close to the scientific facts, was comprehensible to students, made learning interesting, and was feasible in the teaching context. However, teaching circumstance were too complex to achieve all criteria of "good" representations simultaneously. Reflection on the criteria made her believe that every representation had limitations. It was like a double-edged sword, as it helped student learning, it might also lead to misunderstandings (Duit, 1991). The incompleteness of representations provided space for her to continually expand her representations.

Lucy needed to transfer the subject matter into forms accessible to students and to represent the content as authentically as possible. This made the transformation act a dilemma, as other researchers have described (Geddis *et al.*, 1993). Developing and presenting multiple transformations was a strategy she used to deal with the dilemma. Then she could compensate for the limitations of representations. In the meantime she could show the many facets of science and meet the needs and interests of different students. As Lucy dealt with dilemmas, she reflected on her own teaching and promoted her own professional growth. This kind of growth seemed to be the same as that in Tomanek's (1994) study.

Shulman (1987) indicated that transformations require a combination of preparation, representation, selection, adaptation, and tailoring to student characteristics. Among these processes, representation seemed to be the most obscure and difficult process of forming new representations. We know little about "how to represent". The findings in this study show that this "how" was modification, specification, combination, or invention in Lucy's case. The process proceeded from Lucy's extensive knowledge; her knowledge also developed during the renewing process. Lucy's expanding representations and her knowledge hold a dialectic relationship. This seems to be the same as Clark and Peterson's (1986) description.

Besides knowledge, time, effort, resources, and support, creativity was also a key factor in Lucy's

renewal of her representations. Invention, as knowledge reorganization (Schon, 1983), showed the creative side of the teacher's thinking. It allowed Lucy to used only simple and inexpensive materials and easily arrive at procedures to represent concepts for special purposes, students, and contexts. This renewing process not only solved Lucy's teaching problems, but also helped her enjoy the self-actualized feeling that accompanied the process of creation. These inner and outer motivations seemed to be the force driving Lucy to renew representations continually.

Facing the existing environment, Lucy knew how to balance her ideals with the expectations held by the society, school administrators, parents, and students; how to utilize hardware and software of the school and community to enrich her representations; and how to ask support from colleagues, school administrators, and the community for biology teaching. Teaching context shaped Lucy's forms of representations but did not prevent her from improving them. For Lucy these components did not seem to act as constraints in the same manner as beginning teachers' construction (Abell & Roth, 1992; Brickhouse, 1993; Tobin & Gallagher, 1987). They acted more like learning conditions where Lucy could test the feasibility of her new representations. Sometimes, they seemed to act as a facilitator that pushed Lucy to use her creative capacity toward solving teaching problems.

VI. Implication

This case study of an experienced biology teacher illustrates that reflection on representations can be an effective approach for professional growth. A teacher's thinking is often a reflection of her representations. The incompleteness of representations opens spaces for her to continually expand representations. Through the expanding process the teacher demonstrates the dynamic, flexible, content specific, context dependent, interchangeable, incomplete, and personal teaching style of representations. This process is based on the teacher's extensive knowledge, and knowledge is developed during the process. The results enable us to further understand the nature of a teacher's lifelong learning.

Perhaps this suggests that teacher educators, especially those involved in in-service education, can encourage teachers to take charge of their own professional growth by helping them to build criteria of "good" representations for reflecting on their representations. Discussion with teachers about reflection on criteria of "good" representations should be illustrated in terms of dilemmas. Helping teachers focus on the dilemmas may empower them to reflect on their teaching, identify dilemmas, locate resources, and manage them within themselves, rather than initiating professional growth from outside their classroom world. Science teacher preparation programs should foster reflection that enables teachers to make sense of classroom events and apply their knowledge to form representations which fit their circumstances. Science teacher educators could then provide alternative suggestions and support for those who are unsatisfied and want to make change, and those who need help.

Further research is required to articulate similar development for other teachers in the same and different subject areas.

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教學表徵的擴展：生物教師個案研究

林曉雯

國立屏東師範學院數理教育學系

摘　要

本研究的目的是探討一位資深國中生物教師，在其教學情境中，如何持續的擴展其教學表徵，以引導學生學習生物學。研究資料的收集方法包括教室觀察、教師晤談、文件收集；全程均輔以錄影、錄音以便事後分析；並以「三角校正」的方法效化資料。研究結果發現(1)個案教師評鑑教學表徵，引發其擴展教學表徵；(2)個案教師安排概念的先後次序，以建構多重的表徵；(3)個案教師收集相關資料，以擴展教學表徵；(4)新的教學表徵是個案教師進行修正、特殊化、組合或創新的結果；(5)新的教學表徵必須經過預試及實際教學的修正。由於教學表徵的不完備性，造成形成表徵的兩難性，教師面對此兩難問題時，一面反省教學表徵的適當性，同時建構多重表徵，以引導學生學習科學。科學教師在擴展多重表徵的同時，不斷的運用、學習、重建相關的教學知識。本研究的啟示是，科學教師可藉由反省教學表徵的適當性，促成教師個人之科學教學專業知識的成長，值得科學師資培育機構及相關研究者參考。