Use root cause analysis teaching strategy to train primary pre-service science teachers*

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Abstract: This study examined the Root Cause Analysis (RCA) teaching strategy on pre-service primary science teachers and instinct pre-service teachers to apply RCA teaching strategy to science curriculums. RCA Teaching Strategy is to coordinates 5 Why Method and Fishbone Diagram. The participants included 18 pre-service primary science teachers and the training courses for 4 hours a week and lasted for 18 weeks. The result shows that pre-service primary science teachers are gradually familiar with RCA teaching strategy and can apply it to science curriculums from microteaching classroom observation and teaching-portfolios. For example, in *The Influence of Heat on Materials* unit, the fifth grade students observed the balloon on the PET bottle soaked in water swelled. Students would brainstorm all causes of balloon swelled with 5-W method, and draw fishbone diagram together. Finally, they found the root cause with Root Cause Analysis.

Key words: Root Causes Analysis teaching strategy; primary pre-service science teachers; microteaching

1. Introduction

1.1 Rationale and importance of this study

When United Nations Educational Scientific and Cultural Organization (1966) represented the *Recommendation Concerning the Status of Teachers*, it mentioned, “Teaching should be seen as a professional career, a type of public service, and it also needed the professional knowledge and specific ability of teachers”. Research about the teaching ability of professional teachers, Shulman (1986) stated the view of Pedagogical Content Knowledge (PCK), including pedagogical content and teaching methods. He mentioned if a professional teacher owns the teaching ability, she/he would know how to transfer his or her understanding into the knowledge students realize. Allen and Ryan (1969) mentioned a training mode for improving teachers’ teaching ability—microteaching, which is applied to the professional development training of pre-service and in-service teachers. It provides them practice surroundings which reduce complicated factors in classrooms and increase a lot of feedback after teaching. Benton-Kupper (2001) stated pre-service teachers think that microteaching was a perfect chance to attain pedagogical knowledge and skills, and there were more and more evidences show that it was an

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effective method to promote teaching skills of pre-service teachers. Researchers further discovered that if we implement microteaching in the science teaching of primary schools, accompanied the primary students' learning performances, teachers would solve tough problems of teaching through the reflection of using the teaching strategy.

1.2 Research objectives

The study will educate pre-service teachers using Root Cause Analysis (RCA) teaching strategy in science curriculums. Through discussion of microteaching with RCA teaching strategy and teaching in fifth grade of primary school, pre-service primary science teachers would promote their PCK ability. The research objectives are:

(1) How is pre-service primary science teachers' application of RCA teaching strategy through microteaching?

(2) How is the relationship between primary students' learning effects in *The Influence of Heat on Materials* unit and pre-service primary science teachers' professional development?

2. Literature of review

2.1 Theory and practice of microteaching

Allen and Ryan (1969) proposed microteaching as a specific mode of teacher training. The characteristic of microteaching is to divide teaching techniques into small sections such as asking questions, reinforcement, and repeatition, and it is a goal to only realize a small amount of sections when training. There are four steps of microteaching: (1) Practicers are told certain techniques. (2) It is held the teaching of certain techniques in 5-20 minutes. (3) The instructor and practicers discuss the advantages and disadvantages when microteaching. (4) Practicers teach again based on feedback of discussion (Allen, 1967; Borg, Kelley, Langer & Gall, 1970).

To the view of microteaching for pre-service teachers, Benton-Kupper (2001) summed up as follows: (1) It helps to confirm the advantages and disadvantages of teaching. (2) It provides chances to communicate with each other. (3) Watching recording would revise teaching techniques. (4) Practicers would produce intelligible thoughts when Microteaching. (5) Through kinds of Microteaching, practicers would learn many teaching strategies and thoughts.

2.2 The ability of Pedagogical Content Knowledge (PCK) of science teachers

Shulman (1986) indicated PCK in accordance with the shortcomings that pedagogical knowledge and content knowledge were separated in America. Compared pedagogical knowledge of expert teachers with novice teachers, Shulman (1987) proposed seven categories of the teacher knowledge base: (1) Content knowledge; (2) General pedagogical knowledge, with special reference to those broad principles and strategies of classroom management and organization that appear to transcend subject matter; (3) Curriculum knowledge, with particular grasp of the materials and programs that serve as "tools of the trade" for teachers; (4) Pedagogical content knowledge, that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding; (5) Knowledge of learners and their characteristics; (6) Knowledge of educational contexts, ranging from the workings of the group or classroom, the governance and financing of school districts, to the character of communities and culture; (7) Knowledge of educational ends, purposes and values, and their philosophical and historical grounds.

2.3 Theory and practice of Root Cause Analysis (RCA) teaching strategy

The objective of RCA is to identify “root cause(s)” so that these latent failures may be eliminated or modified and future occurrences of similar problems or mishaps may be prevented (National Aeronautics and Space Administration, NASA, 2003). Some fire-fighting is carried out in order to handle and recover immediately. Since this expeditious approach deals with the patching up symptoms quickly, the problem seems temporarily solved. Over time, the problem is likely to recur, thereby eliminating or reducing the anomalous impact. The critical importance of is this prevention of recurring failures (Envision Software, 2003).

HONG (2006) stated when we “confirm the reason” during problem solving process, we try to analyze by native, reliability, and consequence. In addition, the analysis method of consequence is 5 why method. 5 why is proposed earliest by Taichi Ohno in Toyota Motor Company. In the company, they had used 5 why to deal with problems by asking “why” consistently (YANG, 2006). LU, HONG and TSENG (2007) had designed inquiry-based learning curriculums through 5 why Scaffolding Guided Questioning. However, they found that students had difficulty to analyze the root causes of problems. It resulted from not finding a auxiliary means for students to display all possible causes. To solve the problem like this, The Quality Assurance Project (2006) proposed that cause-and-effect diagrams can reflect either causes that block the way to the desired state or helpful factors needed to reach the desired state, which named “fishbone diagram”. The fishbone diagram helps teams to brainstorm about possible causes of a problem.

Above all, this study will develop pre-service teachers’ application of RCA teaching strategy by microteaching. And it emphasized that how re-service teachers attain PCK, curriculum knowledge, and knowledge of learner.

3. Research design

3.1 Research design and procedure

At first, we had pre-service teachers RCA teaching strategy training, including the theory and practice of RCA, 5-W teaching, fishbone diagram using, lesson plans and learning sheets editing, and microteaching. After that, we actualized Microteaching of *The Influence of Heat on Materials* unit, and the courses were altogether for 9 weeks. Finally, pre-service teachers taught in practice at a primary school in Taipei County. We analyzed the relationship between primary students’ learning effects in *The Influence of Heat on Materials* unit and RCA teaching strategy of pre-service teachers.

3.2 Research tools

3.2.1 Fishbone diagram

We used “fishbone diagram” to assist learners finding the root causes of problems. The steps are: (1) The team agree on the problem or the undesired state and write specifically on the right of the paper, and draw a backbone from left to right side; (2) The team can gather data and brainstorm first about likely causes and fill them on the correct branches or sub-branches; (3) Keep asking why and why else for each cause until a potential root cause has been identified, maybe 4-M (men, mechanism, materials, and methods) included; (4) Check the logic of the chain of causes and ensure that the answers to the W-questions are plausible explanations; (5) Generate solving strategy, and write it on the right side under the problem (NASA, 2003; The Quality Assurance Project, 2006).

3.2.2 Observation records of microteaching

The Observation Records of Microteaching was edited by HONG and LU (2007) and includes conceptual communication and supportive communication. Conceptual communication includes RCA application, experiments demonstration, and teaching contents; supportive communication includes language expression, teaching aids, and learning sheets. It summed to 18 items and was approved from 3 professors of National University majored in science education of in content validity.

3.3 Participants

In this study, there are 18 primary pre-service science teachers of third grade at Department of Natural Science Education in a university of education in northern Taiwan. They were divided into six groups by themselves, and each group had three persons. Primary pre-service science teachers had the ability of critical thinking and the knowledge of general biology, general physics, and general chemistry.

3.4 Data collection

Table 1 shows that the purposes and training curriculum of collecting each qualitative item. We collected data from fishbone diagram, observation records of microteaching, and learning portfolio, and feedback list of teaching in practice. Then we did interpretive analysis and triangulation to summarize the results.

Table 1 The purposes and occasions of qualitative data in training courses

Data collections	Purposes	Occasions
Fishbone diagrams	Help teams to brainstorm about possible causes of a problem, and could be an auxiliary means of RCA teaching strategy	(1) Theory and practice curriculums (2) Microteaching (3) Teaching in practice in a primary school
Observation records of microteaching	Observe per-service teachers' promotion of conceptual communication and supportive communication	Microteaching
Learning portfolio	Observe the reflection, thinking, and critique after teaching training	(1) Theory and practice curriculums (2) Microteaching (3) Teaching in practice in a primary school
Feedback list of teaching in practice	Pre-service teachers discuss the effectiveness with instructor and peers after teaching in practice	Teaching in practice in a primary school

4. Results and discussion

4.1 The effectiveness of using RCA teaching strategy through microteaching

4.1.1 The learning effects of theory curriculums

In RCA teaching strategy course training, three teaching sessions and the improvement of pre-service teachers and learning-portfolios are shown in Table 2.

Table 2 RCA teaching strategy of learning-portfolios

	First learning-portfolios	Second learning-portfolios	Third learning-portfolios
Acquire RCA concept	7 persons (39%)	16 persons (89%)	14 persons (78%)
Partially acquire	4 persons (22%)	2 persons (11%)	4 persons (22%)
Not acquire RCA concept	7 persons (39%)	0 person (0%)	0 person (0%)
Total	18 persons (100%)	18 persons (100%)	18 persons (100%)

Table 2 shows that for pre-service teachers to flexibly apply the teaching method, three teaching sessions were conducted. After that, they understood to design RCA teaching strategy. Result shows that finally 78% of pre-service teachers understood the spirit of “RCA teaching strategy” and were able to apply it in their teaching.

4.1.2 Applying RCA teaching strategy to primary science curriculum

RCA teaching strategy and self-designed course plan learning are shown in Table 3.

Table 3 Evidence of student thinking and RCA ability

RCA teaching strategy learning portfolio	RCA teaching strategy classroom discussion
S (majority): It is applicable in science teaching because the question and answer method best arouses students’ curiosity, and the motive to learn. Students will practice to think with structuralized logics and the thinking modes also help cultivate students’ feasible thoughts.	S13: In RCA teaching, do we must represent the results that are also interesting to students? T: Yes, the widespread application of RCA is in medical area, and it is usually used in accidental results in hospitals. When transferring it to apply in the teaching, we can also show the result first to attract students’ concern, and then do RCA.

4.2 The relationship analysis between primary students’ learning and pre-service teachers’ professional development of PCK

4.2.1 Primary students’ learning effects in *The Influence of Heat on Materials* unit through RCA

We viewed primary students’ learning effects in *The Influence of Heat on Materials* unit Through Fishbone Diagram. We took the problem, “Why did the balloon not swell when putting PET bottle in water?” for an example.

(1) When student groups discussed the reasons with fishbone diagram, we found that certain of groups focused on the causes from balloons, and others focused on the size of PET bottle, the content of the bottle, or being heated of the bottle. Students could not consider each kind of aspects with great detail.

(2) Teachers pasted the fishbone diagrams of those six groups, and students discussed more after seeing others’ representations. Each group paid attention to the detail they didn’t come out before.

(3) Next, the class drew a complete fishbone diagram together under teacher’s guidance. It is shown in Figure 1.

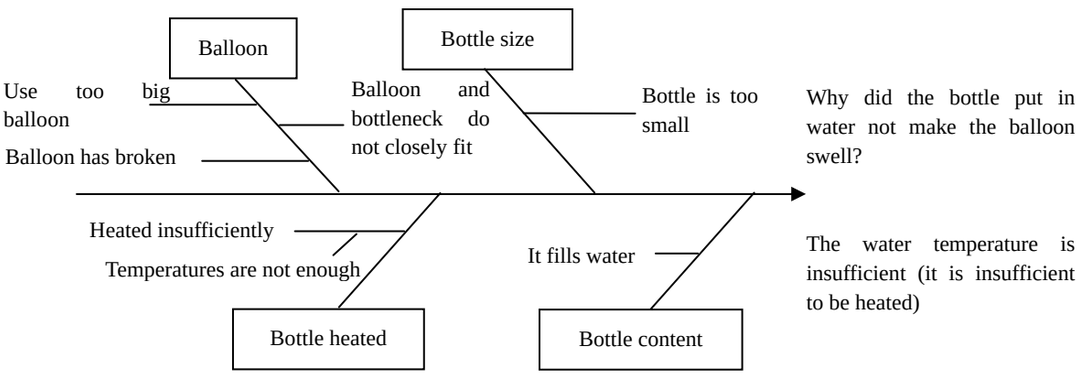

Figure 1 A complete fishbone diagram under teacher’s guidance

(4) Finally, students use “falisificationism” to determine the root cause. It is the water temperature that the bottle could not make the balloon swell.

4.2.2 Primary pre-service science teachers’ professional development in PCK

4.2.2.1 Pedagogical content knowledge

When teaching in practice in a primary school, we found that teachers should guide students applying RCA to solve problems step by step although they were already fifth grade students. In 5-W asking, students would get used to teacher's questioning way. At first, students answered teacher's questions, and then students gradually asked questions and discussed with each other. In instructing fishbone diagram, the teacher gave group students a piece of white paper so that they drew the fishbone diagram by themselves. However, students felt difficult and indecisive. In this situation, the teacher tried to take problems of daily life for example. Teacher drew a backbone, guided students propose cause categories and filled them on the correct branches or sub-branches. After that, students considered every possible cause of each category. Finally, students could canvass and draw the fishbone diagram on their own, also find the root cause. So teachers' action research in microteaching, we revised the steps as follows:

(1) At first, the teacher takes a problem of daily life for demonstration about how to apply fishbone diagram. Next, teacher draws the backbone and blanks which students should fill, and guide group students to discuss step by step, filling the answers in those blanks.

(2) After practicing several times, the students will be familiar with fishbone diagrams.

4.2.2.2 Curriculum knowledge

From observation records of microteaching, pre-science teachers ignored the using details of experimental materials and experimental skills. It resulted in failures or rough experiments, and teachers began to realize it through discussion in classroom and senior teachers' demonstration. Next, from learning portfolios, we found that pre-service teachers gradually chose the experimental materials suitable for students' levels and explained the details of using according to students' ability of experimental skills.

4.2.2.3 Knowledge of learner

Through evaluating students' fishbone diagrams, pre-service teachers did not notice the illogical parts in their fishbone diagrams. After group discussion, brainstorming, and other pre-service teachers' opinions, he/she helped students to focus on the reasonable and logical causes. The class listed all possible causes, and drew a complete fishbone diagram. Meanwhile, they thought about all likely causes by falsification so that students would develop their ability of causal thinking.

5. Conclusion and recommendation

5.1 Conclusion

After three teaching sessions of the theory curriculums were conducted, pre-service teachers could realize the characteristics of RCA teaching strategy and apply the teaching strategy to primary science curriculums. In students' learning effects through RCA, we found that some groups could not think the whole causes thoroughly. Students finally complete the Fishbone Diagram under teacher's guidance. And in pre-service teacher's professional development after teaching in practice in a primary school, they have known that teachers should guide students applying RCA to solve problems step by step although they were already fifth grade students, and they learned to choose the experimental materials suitable for students' levels and explain the details of using according to students' ability of experimental skills.

In finding root cause process, students have learned to not believe those direct causes easily. This strategy

can improve the shortcomings of only solving the single incident, tackling a problem on the surface but not at the root. It would train students to hold doubtful attitude toward anything being seen at the moment, so it reduces the opportunity to judge the reasons by mistake. Also, students know t what data they missed before and what aspects they should reinforce in order that they can think completely. However, using RCA teaching strategy in class, teachers can only analyze and discuss to the single problem which should not be too complicated.

5.2 Implication

RCA teaching strategy is a method of finding out the root causes, and it develops students' habits of thinking all likely causes. On the one hand, teachers could apply the teaching strategy to other suitable units in science curriculums. On the other hand, when selecting topics, teachers should consider that the cause kinds will not be too broad. Once the topics are too complicated, too many causes would let students out of focus. So, when teachers use RCA teaching strategy, they should think twice about choosing suitable problems for students.

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