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A Case Study on the Teaching Behavior of Novice Physical Science Teachers in Secondary School†

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ABSTRACT

Five novice physical science teachers from the Physics Department of X Normal University were selected as subjects of this study. Data was collected in three phases: the first phase occurred during the midterm of the first semester, the second phase during the final term of the first semester and the third during the midterm of the second semester. Methods of data collection in each phase consist of in-depth interviews includings a structured interview and an unstructured interview, classroom observations with tape recordings, and an investigation of students' perceptions of teaching. All the raw data was validated by triangulation and analyzed step by step involving the scientific methods of classification, induction, synthesis, and deduction. The study's general discoveries were made during the first step of analysis, while major assertions were made after further analysis of the general discoveries. Finally, conclusions were drawn from a synthesis of learning psychology, cognitive theory, and epistemology. This study revealed the following facts:

(1) The selected novice teachers believe in objectivism (including both realistivism and empiricism), and tend to teach their students by following the text exactly and doing the experiments as if they were cooking from a recipe.
(2) They seem to share such teaching strategies as giving oral explanations, outlining contents on the blackboard, directing students' learning via asking convergence questions or problem solving, controlling classroom order, repeating important concepts shortly after students answer questions, doing experiments in a recipe style, controlling lab order, and looking after each group's experiments.
(3) Their knowledge of teaching strategies is not sufficient.
(4) Their knowledge of lab teaching strategies is not sufficient.
(5) Their knowledge of individualized instruction and individualized teaching strategies is not sufficient.
(6) Their knowledge of constructivism and constructivist teaching strategies is not sufficient.
(7) Their knowledge of interaction and interactive teaching strategies is not sufficient.

Key words: teaching behavior, teaching belief, objectivism, constructivism.

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I. Introduction

The fundamental purpose of a normal university in the Republic of China is to educate qualified teachers. A science major student has to take four years of science major courses (such as Physics, Chemistry, Mathematics, English, etc.), as well as educational courses (such as Psychology, Learning Theories, etc.), before he can become a qualified teacher. Only after passing and completing all the requirements, will he be sent to begin his fifth year teaching practice, the novice teacher training. If he passes this training, he will receive his diploma and a high school teaching certificate.

The goal of the training in the fifth year is to provide novice teachers chances to link educational theories to real teaching situations, there by constructing their own teaching methods (which correspond to their personalities and suit the needs of this era). This teaching training is vital in that it influences not only the growth of the teaching capabilities ofthe novice teachers, but also the success or failure of upgrading the quality of science education in this country.

Chiang (1993, 19941, 1994b) listed a number of variables that influence teachers' teaching quality, such as personalities, professional knowledge, teaching beliefs, instructional skills, social environment of schools, etc.. What influences affect the novice science teachers? There are very few studies on these influences. In this study, we will apply the methods of in-deep interviews, tape-recordings, and collected student perceptions to gather effective data to analyze the following research questions.

1. Research Questions and Objectives

Our study will deal with whether or not graduates from the Physics Department of X Normal University possess sufficient knowledge of pedagogy and teaching capabilities to teach physics in secondary schools. We will try to answer the following research questions that have been designed for this study:

Question 1: What kinds of teaching knowledge have novice teachers learned?
Question 2: What kinds of teaching knowledge do they lack ?
Question 3: Will novice teachers' conception of science knowledge influence their teaching behavior?

2. Terminology

Several proper terminologies often used in the study are defined as following:

(1) Skillful Performance with time-serial change
Refers to the condition in which the novice teacher has become more and more skillful in the application of his teaching strategies because of the longer duration and frequent use of those strategies.

(2) Improving Performance with Time-serial Change
Refers to increasing frequency of application of teaching strategies because of the longer duration of use of those strategies.

(3) Decreasing Performance with Time-serial Change
Refers to decreasing frequency of application of teaching strategies because of the longer duration of use of those strategies.

(4) Teaching Belief
A basic teaching concept derived from the teacher's evaluation of his own attitude toward the related teaching pedagogy with reference to his own pedagogical knowledge, experiences, social viewpoint or emotion.

(5) Objectivism
A belief that scientific knowledge is objective, that is, there is absolute truth in nature. By truth is meant that the scientific knowledge discovered is compatible with reality.

(6) Constructivism
A belief that there is no absolute truth in nature. In other words, reality is subjective. Many scientific laws, theories and points of view do not exist in the real world but are invented by man's wisdom.

3. Limitations of the Study

(1) Because the qualitative study was time-consuming, only five physical science teachers were chosen as subjects of this study.

(2) Because the qualitative study included field observations and interviews, the subjects were limited to teachers around Kaohsiung City, Kaohsiung County and Pingtong County.

(3) The subjects were further limited to graduates from the Physical Science Department of X Normal University with the view that they could

work reliably with the researcher.
(4) Due to the limited number of subjects, there are no accessive inferences made in this study.

II. Literature Review

This review includes Part I which deals with the meaning and characteristics of belief, and Part II which deals with teaching behavior and teaching beliefs.

1. The Meaning and Characteristics of Belief

Scholars have different interpretations of the definition of belief. Lee (1933) considered beliefs as a guidance for external behavior and internal decisions, having various contents and being faithfully kept by individuals. Somewhat related to the idea in constructivism that knowledge is in-born, although beliefs may change, it may only be with difficulty. Beliefs are partially discernable, partially potential and sometime even undetectable to the individuals. Therefore, he pointed out, to prove the existence of beliefs, we need ample direct and indirect data.

Cornett (1990) asserted that beliefs and practical theories come from an individual's previous living and teaching experiences. These experiences shape his teaching behavior.

Tobin (1992) regarded beliefs as planning patterns of knowledge existing in the individual that drive him toward a certain goal and affect his external activities.

Tuan (1991) pointed out that beliefs may guide in-service teachers' individual actions. They are like a survival truth to the teachers that must be proven and supported by their own experiences.

Clark and Peterson (1986) and Tuan (1991) pointed out that many scholars used different terms for "beliefs", such as "teacher's personal perspective," "conceptual system," "principles of practice," "construct system," "practical knowledge," "implicit theories," and "orientation," etc.. Though somewhat different, these terms share one thing, that is, teacher's cognition and behavior are guided by their personal belief system, or value system. It is beliefs that make teachers' behavior more meaningful (Lee, 1993).

What then are the characteristics of beliefs? Nespor (1985) pointed out that beliefs have some of the important characteristics of "existential presumption", "alternative," and "affective and evaluative aspects". Of these characteristics he asserted that "affective and evaluative aspects" strongly affect the teachers' formulation of their individual idea of value, which further develops into their particular value system. This value system will evolve into a new belief by taking in other compatible systems. Beliefs and value system, therefore, are considered as a whole with two facets, and complement each other. Interacting with thinking, they are the headquarters for study and problem solving.

According to the characteristics mentioned above, beliefs could be classified as "existential presumption belief," "alternative belief," and "affective and evaluative belief". A brief definition for each will be explored in the following:

(1) Existential Presumption Belief

Abelson (1979) pointed out that the belief system usually involves some assumptions, which he termed assumption belive. For instance, if someone presumes that god exist, he would behave piously and wish that god's love could make his dream come true. Nespor (1985) revealed that teachers' presumptions of their students' characteristics, such as their ability, maturity, laziness, etc., would also mirror their teaching behaviors. For example, if teachers assume that their students' poor study performance results from their inability, then they would reduce the level of difficulty of the instructional content, assigning easier drills and homework. If, however, the poor performance is due to too abstract contents, then they may resort to more practical lab work as their instruction strategy.

(2) Expectant Beliefs

Nespor (1985) pointed out that a belief system includes expectations of certain things. For example, many teachers try very hard to set up special models of interaction with their students. The models might not be learned during their school years. For instance, a teacher might have been expecting a model of cordial and interesting teaching activities since his student years. Nevertheless the model might not belong to any teaching theories he had learned. Now that he is a real teacher, he doubtless would make his dreams come true when designing teaching activities.

(3) Affective and Evaluative Beliefs

The formation of affective and evaluative beliefs is mainly due to such factors as personal feelings, moods and subjective evaluations. Generally speaking, belief systems are affected more by affective and evaluative beliefs than by knowledge systems. Abelson (1979) and Nespor (1985) pointed out that teachers usually evaluate each part of curriculum contents according to their affective and evaluative system. Meanwhile they will reflect their evaluation in teaching behavior. Thus affective and evaluative beliefs affect teachers' involvement in teaching activities.

What variables do teachers get their beliefs from? Referring to the schema chart of teachers' practical knowledge vs. their teaching behaviors developed by Duffee & Aikenhead (1992), this study constructed Figure 1 to clarify the relationship between belief system and teachers' teaching behavior (Chiang, 1993, 1994a). This figure indicates that a teacher's belief system is mainly influenced by the teacher's past experiences and his teaching environment. These past experiences include the teacher's educational experiences, such as pedagogy of cognitive education, scientific knowledge, educational theories and strategies (Aikenhead, 1984; Duffee & Ailenhead, 1992; Lantz & Kass, 1987), and the teacher's experiences from living and teaching. The teaching environment includes school administrative style, curriculum structure, software and hardware equipment, and the interaction among colleagues, students and the local social environment. (Duffee & Aikenhead, 1992).

Synthesizing the various theories of teacher's

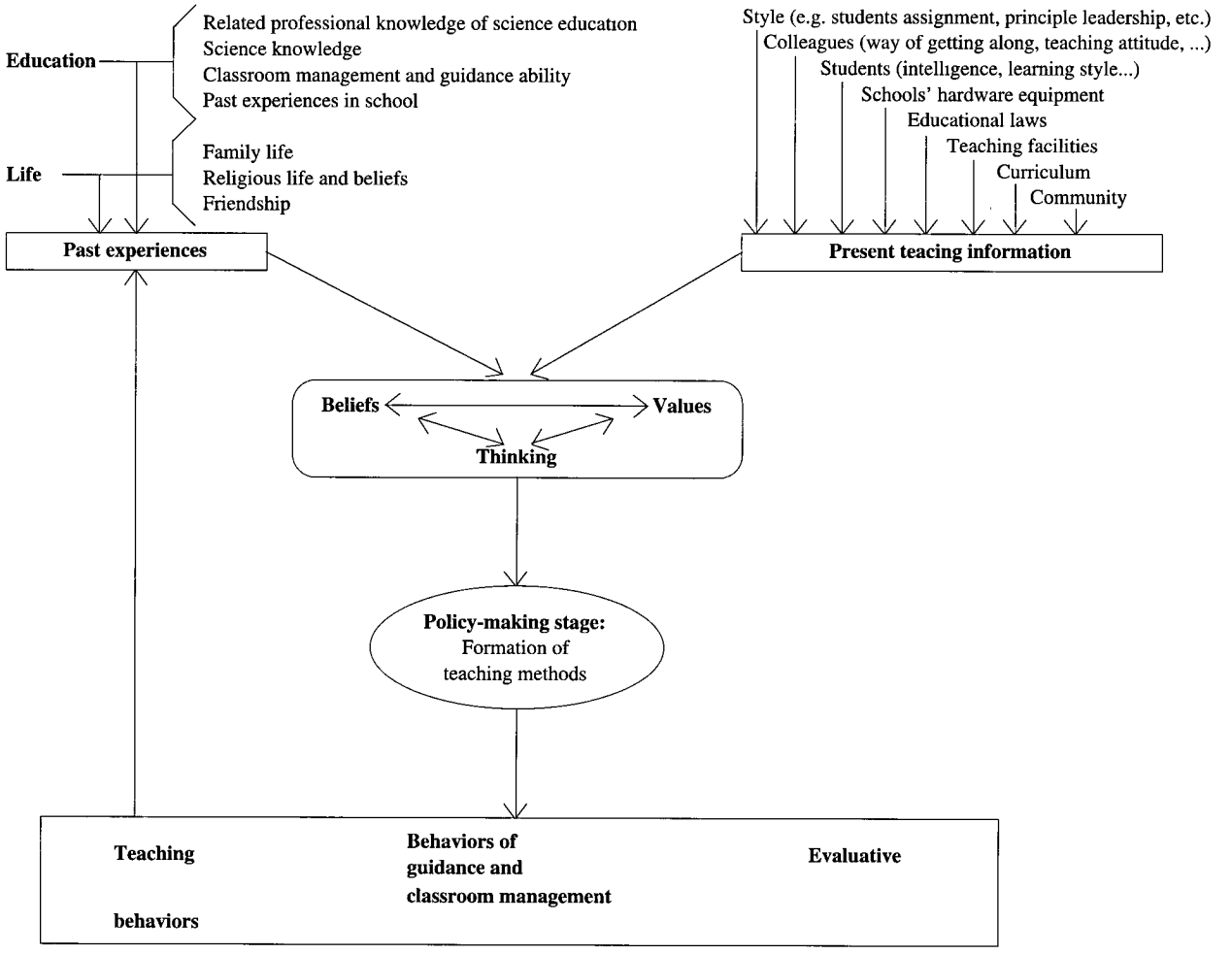

Fig. 1. Flow chart of teaching behavior and teacher's belief system

belief mentioned above, we obtain the following conclusions: Teacher's teaching belief is the sum of the elemental teaching concepts and attitudes based on a teacher's own knowledge, logic, experience, social viewpoint, and emotion, etc. Teaching beliefs construct teachers' belief system which will direct their teaching strategies and behaviors.

2. Teaching Behavior and Teaching Beliefs

From what has been mentioned above we know that teachers' teaching behavior, class management, and evaluation are all deeply influenced by their belief system. Theoretically, we can analyze the interaction between teacher behavior and belief system via the effective data from in-depth interviews and field observations. However, some studies showed that the variables influencing belief systems are too complicated and nonlinear, and that they sometimes give belief and behavior more of a nonlinear relation. Nevertheless, a teacher's teaching behavior controlled by his belief system will never change. Here we will offer some examples of actual research to explain the interaction between teachers' belief systems (or value systems) and their teaching behavior, class management, or evaluation:

Cornett (1990) applied the qualitative research method to a 20-hourclass observation and formal and informal interviews in order to investigate the beliefs of a science teacher who taught gifted and ordinary students. He also analyzed how these beliefs influenced her behavior in the classroom. Results of this study showed that the teacher possessed seven important teaching beliefs that had affected her teaching behavior. The interaction between them will be discussed as follows:

(1) Believing in the Importance of Visual Learning

The case teacher believed "to see is to believe". For example, to illustrate the process of geothermal energy pushing through the earth's crust, she would kneel down and ask two of his students to hold their hands above her head. Then she pushed straight through the students' hands. In this way she gave a visual demonstration of the process of how geothermal energy pushes through the surface of the earth.

(2) Believing in the Importance of Talking in the Student's Terms

The case teacher illustrated scientific concepts by resorting to the students' experiences and languages. For instance, to illustrate the concept of sinking ocean plates she had two students push each other to simulate it. At the same time, she would explain the ocean plate concept by using students' language. .

(3) Believing in the Importance of Interesting Science Learning Activities

The case teacher believed that making science learning fun could stimulate students'participation in the teaching activities. For instance, she took her students outside the classroom to gather soil samples in order to show them different kinds of soils. This process of learning helped stimulate students' interest in joining in her teaching activities.

(4) Believing in the Importance of Higher Levels of Learning

The case teacher provided her students many problem-solving activities, trying to help them relate to the concepts that they had learned. She also asked them higher levels of problems to stimulate their thinking abilities. As for the gifted class, she frequently asked more divergence questions.

(5) Believing in the Importance of Discipline in Class

The case teacher demanded that her students to behave themselves in class. She walked around the classroom to maintain classroom order.

(6) Believing in the Importance of Reinforcement

The case teacher considered it important for her students to learn through a variety of learning strategies. For instance, during class hour she would have her students read their textbook first before using a projector, pictures or peer discussion to illustrate the related contents and concepts in their reading..

(7) Believing in the Importance of Saving Students' Dignity

When they had made errors, students were usually given another chance to correct themselves instead of receiving immediate blame. Cornett regarded this as a case of influence upon the teacher's teaching strategies or teaching be-

havior from their own personal teaching beliefs.

Various similar cases are found in studies by Ching-ee Chang (1992), Hollon & Anderson (1987), Tuan (1991), Thompson (1984), Brickhouse (1989a, 1989b, 1990) and Tobin & Frase (1989). Synthesizing the related literature mentioned above, we knew that the same methodology and procedure could be applied to process the analysis in this study.

III. Methods

This study adopted the time-series method designed by Campbell and Stanley(1963) to collect the related qualitative and quantitative data in three phases. Figure 2. shows the folw chart of study design and related tasks which inclued quantitative and qualitative studies:

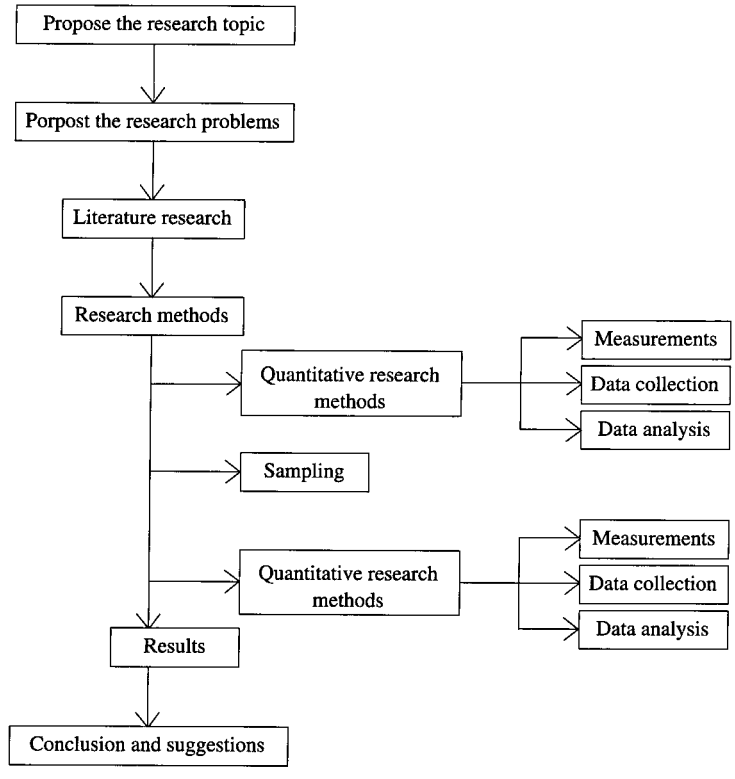

Fig. 2. Flow chart of study design and related tasks

1. Quantitative Study

There are two kinds of quantitative study. One consists of collecting students' perception data about their science teachers' teaching in order to estimate the reliability of video records taken in the classes; the other consists of collecting data during the three phases via video records, in-depth interviews, documents, etc., to analyze the time series change of teaching strategies used by the novice teachers. These changes were classified as skillful performance, improving performance, and decreasing performance with time series change. Following is a detailed description:

(1) Students' Evaluative Questionnaires About Their Science Teacher's Teaching

Questionnaires were developed by Chiang (1994). They include the 22 questions shown in Table 2. Question #1 through #18 are signed as Lkert Scale most agreeable, agreeable, no comment, disagreeable, and most disagreeable. The test-retest reliability was 0.77*** (***P<0.001). Data collection was processed in three phases as

shown in Table 1.

The contents of questionnaires were recategorized according to teaching strategies following Table 2. The selected items were translated into numerical scores, such that the most agreeable item equaled a score of 5, the agreeable item equaled a score of 4, etc.. thereupon the data were analyzed via variance analysis.

(2) Materials That Were Video-Recorded in Class

Teaching activities data that were video-recorded in class are shown in Table 3, while those in the science lab are shown in Table 4. These data can be analyzed by T-Test or F-Test, and also by qualitative study.

2. Qualitative Study

The goal of the qualitative study is to investigate the values or beliefs that dominate the teaching behavior of novice teachers, especially viewpoints of science knowledge, educational ideals, and teaching ideals. To attain this goal, we need to collect sufficient effective data from various aspects, different environments and time series change through different methods of data collection, such as video recording, questionnaires of students' perceptions, and semistructured and unstructured in-depth interviews. In a word, the methods of qualitaative study are flexible and mobile in this research. Interviews of the study, data collection and data analysis are described in detail as follows:

Table 1. Phases of data collection and samples of students' evaluative questionnaires

Phases	Period of Collection	Samples of Students
Phase 1	From Oct. 7, 1993 to Nov. 4, 1993	Teacher A (3 classes): 129 Teacher B (3 classes): 135 Teacher C (3 classes): 137 Teacher D (3 classes): 120 Teacher E (4 classes): 180
Phases 2	From Dec. 16, 1993 to Jan. 20, 1994	Teacher A (3 classes): 123 Teacher B (3 classes): 129 Teacher C (3 classes): 137 Teacher D (3 classes): 122 Teacher E (4 classes): 174
Phases 3	From Dec. 11, 1994 to Apr. 20, 1994	Teacher A (3 classes): 122 Teacher B (3 classes): 124 Teacher C (3 classes): 129 Teacher D (3 classes): 116 Teacher E (4 classes): 176

(1) Interviews

Several semistructured and unstructured interviews given during the qualitative study were classified as following.

(A) Semistructured and unstructured interviews with school principals and supervisors from each case teacher's school at the beginning of the school year.
(B) Semisturctured interviews with case teachers abut their background information, including their childhood information, given at the beginning of school year.
(C) Three semistructured interviews concerning the change of case teacher's teaching behavior and teaching beliefs. The second and the third semistructured interviews are shown in Table 5.
(D) Two semistructured interviews with the science supervisor at the beginning of the first semester and at the midterm of the second semester.

(2) Data Analysis

The methods of categorizing, induction, deduction, synthesis, and triangulation were applied in the data analysis of this study. The following is the flow chart of data analysis:

VI. Results

The discussion of this study will focus on the following two aspects:

- The Time-Serial Change of Novice Teachers' Behavior in Class
- The Time-Serial Change of Novice Teachers' Behavior in the Lab

The related analysis is described as following:

1. The Time-Serial Change of Novice Teachers' Behavior in Class

The types of teaching behavior in class are defined in Table 6.

Following the definitions mention above, each novice teacher's teaching behavior will be discussed as follows:

(1) Teaching Behavior Before Class

The teaching behaviors of case novice teachers before class are generally defined in Table 7.

Table 2. Recategorizing "Students' Evaluative Questionnaire of Science Teaching"

Teaching Strategies	**Category of Students' Evaluative Questionnaire**
1. Using supportive graphs to explain or help students think and learn.	6. Our teacher is good at using supportive graphs to help our thinking.
2. Directing students to apply formulas or concepts to answer questions.	7. Our teacher is good at guiding us to say the formulas related to the lesson. 8. Our teacher is good at guiding us to aply the formulas to solve problems. 9. Our teacher will give similar or related explanatory questions after teaching a formula.
3. Using demonstrative experiments to help concrete think and learning	13. Our teacher often uses demonstrative experiments.
4. Using examples to give explanations	9. Our teacher will give similar or related explanatory questions after teaching a formula. 14. Our teacher often mentions the phenomena of daily life in discussions.
5. Using group learning or discussion.	16. Our teacher's teaching is often conducted through discussion. 17. Our teacher often allows us to discuss freely in the lab class.
6. Using homework.	1. I can do most of the homework given by my teacher.
7. Attracting students' attention in class.	5. Our teacher often allows us to discuss freely in the lab class.
Students' Perceptions	**Categories of Students' Evaluative Questionnaire**
1. Perception of teachers' style	3. Our teachers' teaching is very lively and interesting.
2. Perception of interest in science	4. The tesaching methods of our teacher can increase my preference for science class 15. I am very much interested in the demonstration experiments. 18. I am very much interested in science.
3. Perception of helping thinking ability.	2. Our teacher's is good at directing us to do exercises through our own thinking. 10. The examples given by our teacher can help us to think and ask questions.
4. Perception of helping learning (or understanding) science.	11. The demonstrations given by our teacher are very helpful to my learning. 12. The demonstration experiments given by our teacher are very helpful to my learning.
Other References and Materials.	19. Can I understand science teaching? ❑ most of them ❑ half of them ❑ some of them ❑ few of hem
	20. Can I understand science calculations? ❑ most of them ❑ half of them ❑ some of them ❑ little of them
	21. Can I understand science experiemtns? ❑ most of them ❑ half of them ❑ some of them ❑ few of them
	22. My science scores in the last monthly test? ❑ 100-80 O 79-60 ❑ 59-40 ❑ under 39

(Please refer to Table 3 for records of teaching activities.):

Before lecturing, teachers would attempt to make the classroom atmosphere suitable for learning. At first, they wouldn't do anything more than calling the roll or giving a lecture in order to keep the class in good order. Later they would try to stimulate learning motivation. Finally they began to teach..

From the point of view of learning psychology we know the objective of teaching behavior before class is to help students concentrate their attention and to arouse their curiosity and motivation to learn a new lesson. It also helps students recall what they have previous learned in order to link it with the new knowledge and thus enhance their learning effectiveness.

How did the five case novice teachers behave

Table 3. Records of Teaching Activities

Items	Y.	N. /H	F. /H	M.
Before Class				
1. Roll call				
2. Pre-lecture discipline in order to keep order				
3. Briefly explain the goal or points of a new lesson				
4. Stimulate learning motives by stories, news, special contents or experiments				
Materials Used in Class				
5. Standardized textbook				
6. Self-designed materials				
7. Supplementary calculation questions				
8. Tests by publishers				
General Strategies Used When Teaching				
9. Asking open-ended or convergence quetions				
10. Asking divergent questions				
11. Studetns answering questions in item 9				
12. Students doing item 11, but without satifying answers				
13. Students answering questions in item 10				
14. Students doing item 10, but with mistakes				
15. Teacher directs students' answering questions				
16. Waits during answering time (until students' have answered)				
17. Teacher outlines lesson on the blackboard				
18. Teaches asks students to take notes				
19. Teacher asks students to solve questions on blackboard				
20. Teacher asks each students to write down answers				
21. Teacher asks students to draw a line under important concepts				
22. Teacher asks students to discuss certain concepts or problems				
23. Using teaching aids (such as models, slides, video tapes, cassette tapes and graphs)				
24. Using simple demonstration experiments				
25. Arranging group study or discussion				
26. Walking around and directing students learning				
27. Asking students to recite contents after teachers				
28. Demandng some students recite contents				
29. Stopping teaching activity and giving discipline lecture				
Strageies of Reinforcement Used in Class				
30. Praising student's correct answers				
31. Criticizing student's errors with guidance				
32. Criticizing students}s errors with displeasure				
33. Guiding a student criticize another's answer				
34. Waiting for an answer and then reviewing important concepts of that quesion				
35. Conducting written test				
36. Practicing calculation problems				
37. Discussing answers on test sheet				
Before the End of Class				
38. Concluding important concepts				
39. Giving necessary homework				

Note: F.=Frequency of perfomrance; M.=Minute; H.=Hour; Y.=Yes; N.=No

before giving their lecture? And what were their time-serial changes? The following analysis will provide a true picture of the pre-class behavior of the five case novice teachers:

Teacher A

The analysis of the video records taken in classes during the three phases, the data from correspondence interviews, and the students' per-

Table 4. Records of Teaching Activities

Items	Yes	No	Feq. /hour	Min. /hour
Before Class				
1. Calling the roll				
2. Pre-lecture discipline in order to keep order				
3. Recalling the flaws of the last experiment				
4. Explaining the goal of an experiment				
5. Safety reminder before the experiment				
6. Explaining the procedure of an xperiment				
Materials Used in Class				
7. Standardized textbook				
8. Self-designed instructional materials				
9. Partly self-designed instructional materials				
10. Guiding experiments in each group				
11. Looking around each group's experimental activities				
12. Stopping experimental activities and reminding of important issues				
13. Writing down experimental data or discoveries on blackboard				
14. Asking students to give experimental records				
15. Asking each group to talk about their experimental discoveries				
16. Asking students to ask about each other's discoveries				
17. Directing students to discuss each group's discoveries				
18. Discussing experimental errors				
Before the End of Class				
20. Summing up importand discoveries and concepts				
21. Request writing of experimental reports				
22. Suggesting improvements in experiment				
23. Inspecting each group's cleanup work				

Note: Frq.=Frequency of performance; Min.=Minute

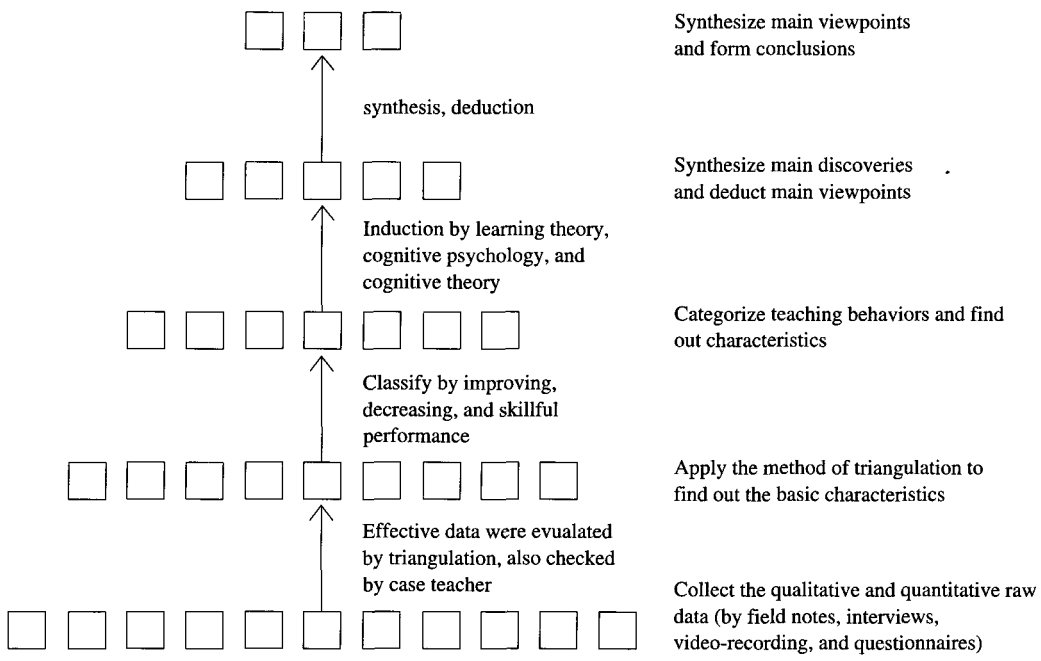

Fig. 3. Flow chart of data analysis

Table 5. Outlines of the Second, and the Third Phase Structured Interviews with Novice Teachers

1. From beginning teaching until now, have you changed any of your teaching goals or beliefs? On what items? and why?
2. From beginning teaching until now, have you taught science following the order, writing style and contents of textbooks? Or have you rewritten them in your own order, style and added some extra materials? Please explain why.
3. From beginning teaching until now, have you changed any methods of experimental teaching?
   The methods are defined as:
   (1) The way of preparing experimental materials
   (2) The way of controlling experimental time
   (3) The way of dividing experimental groups
   (4) The way of writing reports
   (5) The way of stating experimental discoveries
   (6) The way of discussing experimental discoveries
   (7) The way of maintaining lab safety or order
   (8) The way of rearranging lab
   (9) The way of determining experimental effectiveness
   Please explain changed items listed above. And the reasons?
4. From beginning teaching until now, have you changed any methods of your teaching? The methods are defined as:
   (1) Lecturing speed
   (2) Lecturing tone
   (3) Lecturing manner
   (4) Blackboard-writing style
   (5) The way of paying attention to students during lecturing
   (6) The way of handling students' noises
   (7) The way of handling sleepy students
   (8) The way of handling students' gossip and messages
   (9) Requesting note-taking
   (10) The habits of self-asking and self-answering
   (11) The way of encouraging students' questioning
   (12) The way of encouraging students' enjoyment of science
   (13) The way of encouraging students' questioning the bottom
   (14) The way of teaching abstract conceptions
   (15) The way of teaching abstract conceptions
   (16) The way of handling students' convergence questions
   (17) The way of encouraging studetns' discussion
   (18) The way of scoring students' notes
   (19) The way of discussing tests
   (20) The way of using tests
   (21) The way of using reference books
   (22) The way of controlling teaching schedule
   (23) The way of controlling learning atmosphere
   Please explain the changed items listed above. And the reasons?
5. From beginning teaching until now, have you changed your methods of experiment teaching?
   The methods are difeined as:
   (1) The way of preparing experiments
   (2) The way of preparing experimental materials
   (3) The way of handling the problem of students who can't see the experiments clearly
   (4) The way of handling important concepts in experiments
   (5) The way of directing students to use important experimental concepts
   Please explain the changed items listed above. And the reasons?
6. From beginning teaching until now, is it easier and easier for you to apply related science knowledge learned in university to explain or direct your science teaching or experimenting? Please describe your perception and the specifics of these problems.
7. From beginning teaching until now, has there been any help (on teaching or living) from the guidance group or guidance teachers of your school? For which items did you hope to get additional help or reinforcement? Please explain in detail.
8. From beginning teaching until now, has there been any help (on teaching or living) given by guidance professors of thephysics department of X university? For which items did you hope to get additional help or reinforcement? Please explain in detail.
9. From beginning teaching until now, have you changed anything concerning students' guidance or class management (such as cleanness contests, class order...), etc.? And the reasons?
10. From beginning teaching until now, have you changed any of your interpersonal relations, viewpoints of colleagues, or viewpoints about being a teacher? And the reasons?

Table 6. Types of Teaching Behavior in Class

1. teaching behavior before class
2. behaviorusing material
3. general behavior when taching
4. behavor using reinforcement strategies
5. teaching behavior before the end of class.

Table 7. Teaching Behaviors Generally Used before Class (Reference from Table 3)

1. calling the roll
2. Pre-lecture discipline in order to keep order
3. Briefly explaining the goal or points of a new lesson
4. Stimulating learning motives by stories, news, special contents or experiments

ception questionnaires, showed that to attract students' attention and stimulate student motivation, teacher A always reviewed or discussed from lecture notes materials that she had given in the previous class before beginning a new lesson. In other words, the teaching behavior before class adopted by teacher A is similar to item #4 listed in Table 7. As a whole, we have observed that this

behavior became better and better with time series change. The following is a discussion of teacher A's teaching behaviors:

Discovery A-1: Teacher A always used prior knowledge as content before teaching a new lesson. He then managed to attract his students and stimulate their motivation through discussion. He became more and more skillful as he gained more teaching experience. Teacher A's teaching behavior before class was "skillful performance" with time-serial change.

Teacher B

The same technique of analysis applied to teacher A was also applied to teacher B. We found that teacher B's behaviors before class were: calling the roll, listing the goals of the new lesson, and giving students learning motivation by demonstrations, or recalling students' previous knowledge or living experience. These behaviors were similar to the items #1, #3, and #4 listed in Table 7. We also discovered that teacher B became more skillful after gaining more teaching experiences. The following is a discussion of teacher B's teaching behaviors:

Discovery B-1: Before teaching, teacher B would call the roll to keep students quiet. He then immediately turned to the learning objectives of the new lesson to get them ready for it. He also gave a demonstration, or triggered students' past experiences to raise their learning motivation. His teaching behaviors became more and more skillful as he used them more. Therefore teacher B's teaching behavior before teaching is "skillful performance" with time-serial change.

Teacher C

In the case teacher C, we found that no matter whether in higher achievement classes or in average achievement classes, the class order was not very good. Students' noise always enraged teacher C who would then reproach them before beginning to teach. Teacher C always gave pre-lecture discipline before class which was similar to item #2 listed in Table 7. The following is a discussion of teacher C's teaching behaviors:

Discovery C-1: Teacher C did not try to trigger students' past experiences or raise their learning motivation before teaching. What he did was to blame students loudly and repeatedly. This kind of teaching behavior clearly showed no improvement with time-serial change.

Teacher D

In the case teacher D, we found his behaviors before class were quite similar to those of teacher C, such as making pre-lecture discipline as the item #2 listed in Table7. The following is a discussion of teacher D's teaching behaviors:

Discovery D-1: Teacher D's teaching behaviors before class were similar to those in discovery C-1. Though he attempted not to scold his students before teaching, he failed.

Teacher E

In the case teacher E we found he always called the roll before teaching. The following is a discovery of his teaching behavior:

Discovery E-1: Teacher E did not try to make his students recall past experiences or arouse their learning motivation before teaching. What he often did before lecturing was to call the roll. This kind of teaching behavior did not involve time-serial change.

Synthesizing the behaviors before teaching of the five case novice teachers, we found both teachers A and B employed the elementary theory of learning psychology to help their students use their prior knowledge and to arouse their learning motivation. Their teaching strategies became more skillful or improved when they gained more teaching experience. Thus inferences from our analysis offered the following points:

Point 1: The beginner teachers will become more and more skillful or improved in their teaching strategies if they used them frequently. This is called "skillful performance" or "improving performance" with time-serial change.

In this study only two case teachers' (teacher A and teacher B) teaching behaviors before teaching corresponded with the theory of learning psychology. By referring to the interview data again, we may make another point as follows:

Point 2: Beginner teachers from the Physics Department of X Normal University did not possess sufficient teaching knowledge and abilities to link their teaching behaviors to the real teaching situation.

(2) Behaviors Using Teaching Materials

Table 8. Materials Generally Used in Secondary School Science Teaching (Reference from Table 3)

1. Standard textbook
2. Self-designed materials
3. Supplementary calculation questions
4. Test sheets by publishers

In this study we define materials generally used in secondary school science teaching as follows:

In addition to standard science textbooks edited by the Ministry of Education of the Republic of China, which are supposed to be the sole materials generally used in secondary school, there are still many different editions designed either by the teachers themselves or by publishers. These science textbooks are used for supplementary calculation questions, or test sheets, for the purpose of preparing students for the High School Entrance Examination, or for different students' achievement tests, or sometime for the teachers' own teaching ideals. What are the behaviors of five case novice teachers with reference to the teaching materials? The following is a discussion:

Teacher A

The interview data, students' perception questionnaire and video recordings were taken in three phases. The data of the first phase indicated that teacher A adopted his self-designed materials in both higher achievement classes as well as in lower achievement classes. When asked for an explanation, teacher A admitted that he was influenced by a science teacher in his senior high who always rewrote textbooks for his students. After analyzing the structure of his teaching materials, we did not find that teacher A had any ideal about the concept of individualized education.

All data in the second phase indicated teacher A had already adopted standard textbooks for his lower achievement classes. In the third phase, the data revealed he even used reference books by other publishers instead of his own materials for higher achievement classes. Discovery A-2 describes the transition of materials used of teacher A in the three phases.

Discovery A-2: After teaching for some time, teacher A's ideals and enthusiasm in teaching dwindled but he became more practical. Getting more teaching experience, he shifted from using self-designed materials to standard textbooks, and then to reference books. We consider teacher A's behavior in adopting materials as "skillful performance" with time-serial change.

Teacher B

The sources of data are similar to those of Teacher A mentioned above. All data indicated teacher B only used textbooks as his teaching materials. Discovery B-2 as follows describes his teaching behavior during the three phrases in the analysis:

Discovery B-2: Teacher B used standard textbooks as the only teaching materials. Hence, there was no time-serial change in his teaching behavior.

Teacher C

The sources of data are similar to those of Teacher B mentioned above. All data indicated teacher C always used reference books by other publishers instead of the standard textbooks. The behavior of teacher C was described as follows:

Discovery C-2: Teacher C only uses reference books as the main teaching materials. Hence, there was no time-serial change in his teaching behavior.

Teacher D and Teacher E

The behaviors of teacher D and E were similar to those of teacher B. Hence Discovery D-2 and Discovery E-2 are similar to that of Discovery B-2. Our analysis of teaching materials showed that only one novice teacher ever designed his own materials. All the others merely adopted textbooks or reference books as teaching materials. From our analysis we can infer the following points:

Point 3: Novice teachers from the physics department of X Normal University place too much reliance on using standard science textbooks and reference books. They

ignore the needs of individual students.

It is a fact that students have individual differences. How did these novice teachers handle these differences? The interview data indicates that they used materials from reference books to cram higher achievement students. As for the lower achievement students, they were often taught with less materials, or some of the contents were just skipped over. Of the five case novice teachers, no one ever seemed ever to care about the problems of individual need. Thus we can make the following point:

Point 4: Novice teachers from the Physics Department of X Normal University have very limited knowledge of designing individualized materials, evaluations, or teaching methods. They always resorted to standard textbooks or reference books for their primary teaching materials.

(3) General Teaching Behaviors During Teaching

In this study we define teaching behaviors generally used during teaching in Table 9.

What were the general teaching behaviors of the five case teachers during their teaching ? How was their performance? Our analysis showed that the following teaching strategies were used in different degrees by the five case teachers:

Table 9. Generally Used Teaching Behaviors During Teaching (Reference from Table 3)

1. Asking open-ended or divergence questions
2. Asking convergent questions
3. Students answering questions in item 1
4. Students doing item 3, but without satisfying answers
5. Students anwering questions in item 2
6. Students doing item 2, but with mistakes
7. Teacher directs students' answering questions
8. Waits answering time (until students' have finished answering)
9. Teacher outlines a lesson on the blackboard
10. Teaches asks students to take notes
11. Teacher asks students to solve questions on blackboard
12. Teacher asks each student to write down answers
13. Teacher asks students to underline important concepts
14. Teacher asks students to discuss certain concepts or problems
15. Using teaching aids (such as models, slides, video tapes, cassette tapes and graphs)
16. Using simple demonstration experiments
17. Arranging group study or discussion
18. Walking around and directing students learning
19. Asking students to recite contents after teachers
20. Demanding some students recite contents
21. Stopping teaching activities and giving discipline lecture

Teacher A

Discovery A-3: Teacher A seldom used strategies like group discussion or group study during his teaching. His teaching strategies therefore displays "decreasing performance" with time-serial change.

Discovery A-4: Teacher A seldom used demonstrations as a teaching strategy, which displays "decreasing performance" with time-serial change.

Discovery A-5: Teacher A often uses explanations as a teaching strategy, which displays "improving performance" with time-serial change.

Discovery A-6: Teacher A understands some methods of effective learning, which present "improving performance" with time-serial change. For instance, he would demand students to solve questions on the blackboard and to underline the important concepts in their textbooks, and to read the important concepts aloud in the class. He would also walk around to direct them in these teaching activities. All this shows that teacher A has realized the importance of students' problems in learning science.

Teahcer B

Discovery B-3: Though teacher B never adopts strategies like group discussion or group study, he often uses open-ended questions to lead his students in a short discussion. His teaching behavior presents "improving performance" with time serial change.

Discovery B-4: Teacher B once adopted a demonstration as a teaching strategy. However, it presents "decreasing performance" with time-serial change.

Discovery B-5: Teacher B often uses teaching strategies such as directing students' answers, making examples and drawing graphs for his interpretation ofthe science text. All these present "improving performance" with time-serial change.

Discovery B-6: Teacher B often uses convergent

questions as a teaching strategy. This also presents "skillful performance" with time serial change.

Teacher C

Discovery C-3: Though teacher C never adopts strategies like group discussion or group study, he sometimes asks open-ended questions. He failed because of the poor answers of his students. Therefore his teaching behaviors present "decreasing performance" with time serial change.

Discovery C-4: Teacher C once used teaching strategies such as directing students' answers, using a simple demonstration and drawing graphs to help make his explanation clear. But all these present "decreasing performance" with time serial change.

Discovery C-5: Teacher C likes his students to solve questions on a piece of paper rather than on the blackboard. This forces students to think hard for the answers. This teaching behavior presents "improving performance" with time-serial change.

Discovery C-6: Teacher C often uses teaching strategies such as asking convergence questions, writing teaching contents on the blackboard, and demanding his students to read from their textbook. These teaching behaviors present "skillful performance" with time serial change.

Teacher D

Discovery D-3: The teaching strategies which teacher D often used are "improving performance' with time serial change, including asking convergence questions, outlining the teaching contents on the blackboard and giving examples to direct students' responses.

Duscivert D-4: The teaching strategies which teacher D often used and was "decreasing performance" with time-serial change include: Asking open-ended questions, drawing graphs for explanation, and using simple demonstrations. Since teacher D could not control students' participation and their order, his teaching was always behind schedule. He did not want to continue these strategies. Thus they present "decreasing performance" with time serial change.

Discovery D-5: Teaching strategies that teacher D never used include asking students to take notes, solve questions on the blackboard, write down answers, discuss certain concepts or problems, engage in group study or discussion, underline important concepts, or recite the teaching contents. Furthermore, he never walked around the classroom to direct students' learning, and never stopped his teaching to give special discipline to his students.

Teacher E

Discovery E-3: The teaching strategies which teacher E often used and was "improving performance" with time-serial change include: Explaining with examples, asking convergence questions, outlining the teaching contents on the blackboard and demanding students answer questions on a piece of paper.

Discovery E-4: The teaching strategies which teacher E always used that present "skillful performance" with time-serial change include: Walking around the classroom while reading teaching contents, stopping his lecture to give discipline to the class, demanding students underline the important concepts in textbooks, etc..

Discovery E-5: The teaching strategies which teacher E once used that present "decreasing performance" with time-serial change include: Using graphs or charts to help explanation, asking each group to discuss certain concepts or problems during reading, arranging group study or discussion, and using simple demonstrations.

By synthesizing the teaching features shown in the teaching behaviors of the five case teachers, we discover that some teaching strategies are never

used, some are used but present "decreasing performance" with time-serial change, some are used at a later phase and present "improving performrnance" with time-serial change, and some are often used and present "skillful performance" with time serial change. Some of the common characteristics will be discussed as follows:

The teaching strategies that all five case teachers often used and present "improving performance" with time-serial changes include: Lecturing (such as graphing and presenting examples to help explanation), outlining subjects on the blackboard, directing students' learning (such as asking convergence questions and allowing students to solve problems themselves), and controlling class order.

The teaching strategies that all five case teachers never used or used once but present "decreasing performance" with time-serial change include: Asking open-ended questions, arranging group study or group discussion, asking students to discuss certain concepts or problems, and using simple demonstrations as teaching aid.

Synthesizing the philosophical viewpoints of the teaching strategies of case teachers,we reach to following conclusion:

Point 5: The five novice teachers basically do not think that students can construct their own scientific knowledge. Instead, they believe scientific knowledge consists of some existing conceptions, rules, principles or laws that can be learned only through teachers' instruction and students' frequent practice.

(4) Behaviors of Reinforcement Strategies During Teaching

In this study we define reinforce strategies that are often used in Table 10:

Next we come to the question of the general reinforcement teaching strategies used often by the five case teachers during their teaching. What are they? How is their performance? By the same methods of analysis discussed previously, during the three phases we discovered that the reinforcement strategies variously used in class by the five case teachers are as follows:

Teacher A

Discovery A-7: Teacher A is not good at using a reinforcement strategy with an emotional feedback function.

Discovery A-8: Teacher A is not good at using the reinforcement strategy of summarizing the concepts that have been taught in the class.

Discovery A-9: Teacher A is not good at using the reinforcement strategy of evaluating critically differences in viewpoints between teachers and students as well as between students themselves.

Discovery A-10: Teacher A emphasized the reinforcement strategy of repeating testing, and it has "skillful performance" with time-serial change.

Discovery A-11: Teacher A used the reinforcement strategy of repeating practice to emphasize the importance of concept learning, and it has "improving performance" with time-serial change.

Table 10. Reinforcement Strategies Often Used during Teaching (Reference from Table 3)

Strategies of Reinforcement Used in Class
1. Praising student's correct answers
2. Criticizing student's errors with guidance
3. Criticizing student's errors with displeasure
4. Guiding a student to criticize another's answer
5. To wait for an answer and then review important concepts of the question
6. Conducting a paper test
7. Practicing calclation problems
8. Discussing test sheet answers
Before the End of the Class
9. Concluding important concepts
10. Giving necessary homework

Teacher B

Discovery B-7: Teacher B also uses the reinforcement strategy of repeating practice to emphasize the importance of concept learning, and it has "improving performance" with time-serial change.

Discovery B-8: Teacher B emphasizes the importance of calculation learning, so he often asks students to do calculation problems.

Teacher C

Discovery C-7: Teacher C is not good at using reinforcement strategies. The only

reinforcement strategy he used was praising.

Teacher D

Discovery D-6: Like teacher A, teacher D is not good at using a reinforcement strategy that has an emotional feedback function.

Discovery D-7: Teacher D uses the reinforcement strategy of repeating practice as teacher B did to emphasize the importance of concept learning, but it has "decreasing performance" with time-serial change.

Teacher E

Discovery E-6: As did teacher A, teacher E prefers to use a reinforcement strategy that has emotional feedback function such as praising or judging.

Discovery E-7: Teacher E prefers to use tests as a reinforcement strategy, and it has "skillful performance" with time-serial change.

Discovery E-8: Teacher E likes to use repeated explanation as the reinforcement teaching strategy to emphasize the importance of conception learning. It has "improving performance" with time-serial change.

Synthesizing the teaching behaviors of five case teachers in using reinforcement strategies, we discover that some reinforcement strategies listed in Table 10 are never used, some are once used but present "decreasing performance" with time-serial change, some present "improving performance" with time-serial change, and some present "skillful performance" with time-serial change. Their common characteristics are inferred as the following:

The teaching strategies that all five case teachers have never used or once used and display "decreasing performance" with time-serial change include: evaluating a student's errors with guidance and guiding students to analyze critically the answer of another student. The philosophical viewpoints of these two reinforcement strategies aim at directing students to construct their own correct science concepts, as well as to develop their creativity. Thus we come to the following viewpoint:

Point 6: Novice teachers did not have enough knowledge about the theories of interactive learning.

Point 7: Novice teachers are poor in their knowledge of constructivism. That is why they give up the interactive learning strategy and emphasize the transmitted teaching strategies of objectivism.

Except C teacher whose reinforcement strategies can not be determined clearly, the reinforcement strategies commonly used by the other four case teachers, and showed "skillful performance" or "improving performance" with time-serial change, are: waiting for the answer and then reviewing important concepts of that question. Synthesizing the philosophical viewpoints of that reinforcement strategy, we discover its main goal is to emphasize the importance of conceptual learning. Thus we arrive at the following inference:

Point 8: Novice teachers strongly emphasize existing and formal science concepts.

Therefore they keep students doing frequently repeated learning.

2. The Time-Serial Change of Teaching Behaviors in Lab

In this study we classified the teaching behaviors in the lab in Table 11. Following are some of the discussions that we have made:

Table 11. Categories of Teaching Behaviors in Lab (Reference from Table 3)

1. Teaching behavior before experiments
2. Behavior using experimental materials
3. Teaching behavior during experiments
4. Teaching behavior before the end of experiments

(1) Teaching Behavior Before Experiments

Video data and the correspondence interview data taken during the three phases all indicated that only teacher A and C had done some lab teaching. The teaching behaviors often used before experiments is defined as in Table 12.

We may then ask the questions: What are the experimental teaching strategies often used by case teachers A and C? How is their performance? We can infer that the characteristics of teachers A and C using experimental materials are as follows:

Table 12. Teaching Behaviors before Experiment (Reference from Table 4)

1. calling the roll
2. Pre-lecture discipline in order to keep order
3. Reminder of the flaws of the last experiment
4. Explaning the goal of the experiment
5. Safety reminder before the experiment
6. Explaning the procedure of the experiment

Teacher A

During the first phase teacher A was very much concerned with the experimental and safety procedures and explained them very carefully before the experiment. Even during the experiment he showed his concern by using the method of adding or deducting points from the scores of each group to have them stay orderly and do the experiment seriously. He directed experiments for each group and inspected their situations. Although he asked each group to give him their experimental data, he did not discuss any of it. The situation during phase II was similar to that of phase I. In the third phase, in order to develop students' ability to operate experimental apparatus by themselves, he asked his students to read experimental materials, such as goals, procedures and safety, etc. by themselves. Of course they could ask their teacher to help them if they had problems.

According to the video recordings taken during the three phases, we did not find teacher A displaying any of the teaching behaviors listed in Table VI-7. Is this discovery true or not? Now we are going to look at it from the three interview data.

The interview data show that teacher A only allowed students in the higher achievement class to do experiments. He would explain the experimental goal (to prove the phenomena or laws in the textbook), remind them of safety and explain the procedure in class (not in the lab) before experiment. During experimenting he would not repeat those points. Students did the experiment as soon as they entered the lab, and he would inspect some groups. That was why the video recording did not present all of his teaching behaviors listed in Table VI-7 and we had to supply it from interview data.

From the data mentioned above we could infer the features of teacher A's lab teaching behaviors as follows:

Discovery A-12: Teacher A's detailed explanation of the goal before experiments shows that he tried to prove certain phenomena and laws, and hence there is no time-serial change.

Discovery A-13: Teacher A's detailed explanation of experimental procedures shows that he used a recipe method to teach experimental activities, and there is no time-serial change.

Discovery A-14: What teacher A did was to train his students how to operate experimental apparatus which basically consists of a skill ability, but not cognitive abilities such as observation or discovery ability. However, this teaching behavior presents "skillful performance" with time-serial change.

Teacher C

During the first phase teacher C wrote down the experimental procedures, objectives and the safety items on the blackboard and explained them to his students. He also directed each group separately and inspected their experiments. The second and third phases were similar to that of the first phase. According to the video data taken in the three phases as well as the corresponding interview data, we find the features of teacher C's lab teaching as follows:

Discovery C-8: Similar to discovery A-12.

Discovery C-9: Similar to discovery A-13.

(2) The Behavior of Using Experimental Teaching Materials

In this study we define the experimental instruction materials often used before experiments as in Table 13:

What were the instructional materials often used by teachers A and C? The features of teachers A and C's using experimental teaching materials are as following:

Teacher A

Table 13. Experimental Teaching Materials Defined in this Study (Reference from Table 4)

1. Standardized textbook
2. Self-designed instructional materials
3. Part of self-designd instructional materials

Discovery A-15: Teacher A used all standardized experimental teaching materials, which indicated no time-serial change.

Teacher C
Discovery C-10: Similar to discovery A-15

(3) Teaching Behaviors During Experimenting.

The experimental teaching behaviors are defined as in Table14:

Table 14. Experimenatl Teaching Behaviors Defined in this Study (Reference from Table 4)

1. Guide experiments in each grup
2. Inspecting each group's experimental activities
3. Stopping experimental activities and reminding of important issues
4. Writing down experimental data or discoveries on blackboard
5. Asking students to give experimental records
6. Asking each group to talk on their experimental discoveries
7. Asking student to ask about each other's discoveries
8. Directing students to discuss each group's discoveries
9. Discussing experimental errors
10. Creating ideas for new experimenta designs

Table 14 reveals that the features of teachers A and C's using experimental materials during the three phases are as following:

Teacher A
Discovery A-16: The experimental teaching goal of teacher A is to prove the theories or phenomena listed in the textbook.
Discovery A-17: Teacher A did not use any strategy of interactive learning in his experimental teaching.

Teacher C
Discovery C-11: Similar to discovery A-16.
Discovery C-12: Similar to discovery A-17.

(4) Teaching Behaviors Before the End of Experiments.

Teaching behaviors before the end of experiments are defined as in Table 15.

The features of teachers A and C's teaching behaviors before the end of experiments are as following:

Table 15. Experiment Teaching Behaviors before the End of Eexperiemtns (Reference from Table 4)

1. Summing up important discoveries and concepts
2. Asking students to write experimental reports
3. Reminding of the improvements in experiments
4. Looking around at each group's cleanup work

Teacher A
Discovery A-18: At the end of the experiment teacher A never did any further discussion or explanation besides trying to prove the theories and laws in the text-book.

Teacher C
Discovery C-13: Teacher C's behavior before the end of the experiment was similar to that in discovery A-18.

Of the five case teachers there were only two who wanted to do science experiments, and one did it only for higher achievement class. In sum, we can infer that

Point 9: For these two novice teachers it seemed that lab teaching was not necessary because they could do it on the blackboard (this is usually termed as "blackboard experiment" and has been very popular with other science teachers). This was why the other three teachers did not do lab teaching.

Point 10: Only few novice teachers from the Physics Department of X Normal University liked to do lab teaching. They formally used the recipe teaching strategy to teach experiments. Their main teaching goal was to prove certain phenomena, rules, laws or principles in the textbook in order to help students deepen their impressions of the scientific knowledge they had learned.

V. Conclusions and Suggestions

Our analysis of the teaching behaviors of five novice teachers from the Physics Department of X Normal University revealed 10 important points as mentioned above. What kind of conclusion can we drawn from these 10 viewpoints? Points 5, 7, 8, 9, and 10 clearly show that many teaching behaviors

of the case teachers were influenced by their scientific professional knowledge. That is, their belief in objectivism (include realistivism and empiricism) affected the way that they taught physical science. Our analysis therefore leads us to the following conclusion and provides possible answers to **research question 3.**

Conclusion I: The case teachers from the Physics Department of X Normal University believe in objectivism (including realistivism and empiricism). Thus they tend to transmit knowledge in the lessons to their students while teaching but use a recipe strategy while instructing lab work .

As mentioned previously, knowledge about teaching skills or strategies that present "skillful performance" or "improving performance" with time-serial change can only be effective under the condition that the teachers already possess that knowledge and are willing to apply it in their teaching. How did the case teachers perform in this area?

Our analysis in the previous section showed that they did not have this knowledge. Two of them, however, always gave their students prelecture discipline, such as demanding quiet or scolding them before they began to teach, which presented skillful performance. Another two usually used different methods to motivate their students before teaching, which also presented improving performance with time-serial change.

With reference to point 3, we found that teaching behaviors using teaching materials were different among the five case teachers. One of them used reference books as the only teaching materials for his higher achievement classes, while the rest solely depended on standard textbooks.

As for "skillful performance" or "improving performance" of teaching strategies with time-serial change, we found that the teachers all shared such teaching strategies as: The strategy of explanation (such as using graphs or living examples to explain a point), outlining contents on the blackboard, directing students' learning (such as asking convergence questions or asking students to solve problems), and keeping the class orderly.

As to the reinforcement strategies used in teaching, we did not find that they had anything in common. Four of them, however, often used reinforcement strategies that presented "skillful performance" or "improving performance" with time-serial change. For example, they might explain important concepts again shortly after students gave correct answers.

The lab teaching strategies used by the two novice teachers with "skillful performance" with time-serial change were: recipe-style lab teaching, control of order in the lab, and looking around at each group's experiment.

In summary, we have reached the following conclusion and provide an answer for **research question 1.**

Conclusion 2: The teaching knowledge that the case teachers from the physics department of X Normal University have in common is: The teaching strategies of explanation, outlining, directing students' learning (such as by asking convergence questions or asking students to solve problems), controlling class order, explaining important concepts again shortly after students' answers, recipe-style lab teaching, controlling lab order, and looking around at each group's experiments.

Next, we come to another question. What conditions do teaching behaviors show in "decreasing performance" with time-serial change? In this study we consider the following two conditions:

The first condition is when the user (or teacher) is not familiar with the teaching skill and his teaching strategy does not show any effects. Therefore why his teaching behavior displays "decreasing performance" with time-serial change.

The second condition is when the user feels more and more uncomfortable with his teaching strategy. Taking the demonstration strategy as an example, some of the case teachers thought it a waste of time doing demonstrations because demonstrations are time-consuming and they had too much regular content to catch up with. That is why they were reluctant to use demonstrations in teaching. Since "blackboard experiments" are more effective, they replaced demonstrations as a teaching strategy.

How are we therefore to differentiate and classify the teaching strategies that show "decreasing performance" with time-serial change? Our analysis is based on interview data with the case teachers as well as the judgment of the writer who synthesized all information concerning teaching strategies.

Why would a teacher seldom apply a certain teaching strategy in his classroom? One answer

could be that a teaching skill is unsuitable for his teaching environment. On the contrary, in this study we found that the reason is due to teachers' lack of basic knowledge of using these strategies, as mentioned in points 3, 4, and 6.

Synthesizing the information in points 2, 3, 4, 6, and 9, we can make the following conclusions and provide answers for **research question 2**:

Conclusion 3: The case teachers' knowledge of teaching strategies was not sufficient.

Conclusion 4: They did not have sufficient knowledge of lab teaching strategies because they lacked training in lab teaching theory and strategies.

Conclusion 5: They did not have sufficient knowledge of individualized instruction theories and strategies.

Conclusion 6: They did not have sufficient knowledge of constructivist theory and strategies.

Conclusion 7: They did not have sufficient knowledge of learning interaction theory and strategies.

According to the conclusions mentioned above, we make the following suggestion:

Suggestion: Due to the limitation of samples in this study, whether the seven conclusions we reached are universal or not is a question requiring of further research.

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理化科實習教師教學行為的時間序列分析研究

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摘　要

有見於實習教師第五年的實習教育目標係提供實習教師有機會將學校四年所學的教育理論和教育實務結合，並建構出符合實習教師個人特質和時代需求的教學知能。因此實習教師第五年的學習成果，不但影響實習教師本身的教學知能，更影響整體教育的品質，而且在實習的過程中更能看出實習教師所學。有鑑於此，本研究將利用時間序列分析法找出實習教師的主要教學知能，以及欠缺的教學知能。研究歷程將分爲三個不同階段：即在實習第一學期的期中和期末，以及第二學的期中，分別進行結構性和非結構性深度訪談、分類法，先找出一般發現，再利用歸納法找出主要看法，最後再利用歸納法，找出主要看法，然後再應用心理學、認知心理學、和知識等，以及歸納法、綜合法和推論法，找出主要結論。

本研究所獲得的結論如下：

結論1：個案實習教信仰客觀主義（含理性主義和經驗主義）的科學知識觀。因此其教學行爲均傾向以講解式爲主，而實驗教學則以食譜式爲主。

結論2：個案實習理化教師共同具有的教學知能是（除本科專業知識外）：講解式教學策略、將講課綱要抄在黑板上、引導學生學習（於問閉鎖式問題、要求學生動手解問題等）、控制教室的秩序、待學生回答問題後，又重複扼要說明該問題的重要概念、食譜式實驗教學法、控制實驗室的秩序，以及分組巡視實驗等。

結論3：實習教師具有之相關教學策略的教學知能不足。

結論4：在上課進行中，實習教師能應用的教學策略不夠多，顯示其具有之教學知能不足。

結論5：在實驗教學中，實習教師能應用之實驗室教學策略不夠多，顯示其具有之實驗室教學知能不足。

結論6：實習教師具有之個別化教學理論和個別化教學策略的教學知能不足。

結論7：實習教師具有之有建構主義的科學知識觀和建構式教學策略的教學知能不足。

結論8：實習教師具有之師生互動，和同儕互動等攸關認知學習的教學知能不足。