Exploring the Underlying Mechanism of PDCA Cycle to Improve Teaching Quality: A Motivation Theory Perspective

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Abstract--**Considering the importance of teaching quality in the field of education, the purpose of this paper is to explore and discuss the underlying mechanism of plan–do–check–action (PDCA) cycle in the education context through the motivation theory. Firstly, the PDCA cycle is applied to design integral implementation steps in the management for colleague students' study to improve the teaching quality. Moreover, the goal setting theory in motivation theory is used to discuss the underlying mechanism of PDCA cycle to improve teaching quality. To understand this, the goal commitment and task complexity are served as moderators of the relationship between the students' plans and performance. Additionally, we demonstrate that the self-efficacy plays as a mediator between the teacher's action and the students' performance. Hypotheses are given and further tested with a sample of third year colleague students in a Chinese University**.

I. INTRODUCTION

The plan–do–check–action (PDCA) cycle is a four-step management method used for controlling the quality of products and sustaining improvement of processes. It was made popular by Dr. Edwards Deming, the father of modern quality control. In the step "Plan", the leader will identify the target and decide what to do to accomplish the target. In the step "Do", the followers will implement those tasks according to the plan, targets and measures formulated in the first step. In the step "Check", the leader will compare the results of the implementation with the requirements of the plan, and check if the execution and implementation of the plan achieve the desired targets. In the last step "Action", the leaders will draw lessons and find out the unsolved problems from the above steps; they will also summarize the successful experiences and give awards to those who attain their plans perfectly [6, 9].

In this paper, we would like to explore the underlying mechanism of PDCA cycle to improve teaching quality based on the motivation theory. Motivation is an internal drive which can encourage people to reach the goals they set for themselves. [1] The motivation theory is deemed to be one of the most important theories in the field of organizational behavior [16].

The motivation theory mainly consists of two different categories of theory, the content theory and process theory. The content theory explains how the internal factors inspire and direct one's behavior. The process theory mainly focus on how thought processes influence behavior. Edwin's goal setting theory and reinforcement theory are among the major process theories of motivation. The goal setting theory supposes that people are motivated to reach goals they set for

themselves, especially when goals are specific [16].

In prior literature, PDCA cycle has been applied to many contexts. It is also a management method of that can be adapted to the study in the organizational level or the individual level [15, 18]. Specifically, to improve the quality process, the PDCA cycle was applied to the enterprise management practice [7, 15]. To promote customer satisfaction, the PDCA cycle was adapted in the combination theories to ensure a corporation has the requisite capability in each PDCA step [4]. Furthermore, based on the PDCA cycle control theory, the process management of logistics customer service performance evaluation from supply chain perspective was studied [21]. In some cases, PDCA cycles and quality criteria were employed to control the learning-process and the surgical quality [12].

More recently, education leaders began to recognize the potential for PDCA cycle to be applied to the educational organizations [3, 10]. For example, Jacqueline S G examined the total quality management in education [10]. They pointed out that the usage of the PDCA cycle-based quality management principles to guide change in schools is due to a variety of reasons. Different from the case in industry, when quality management comes to education field, conventional ideas, specifically how to manage the teaching/learning process, have to be changed. In any case, education could be improved through quality management.[24] Therefore, the industrial model could not be transferred directly and fit into the educational context. An 11-step "improvement decision model" was established to enhance teaching quality [5].

In the context of teaching management, the PDCA cycle order was used in TQM perspective to connect the teaching management decision-making system, the implementation system, monitoring system and processing system organically so as to form a closed teaching quality management chain [22]. For example, Zhao F H studied whether the PDCA circle can be used in the university education and how to apply it [23]. It demonstrated that teaching quality and teaching process interact with each other, and the four stages of PDCA in teaching process interact with each other as well. In order to improve the level of the university education, the focus of educational reform has been implemented on the specialized courses in China's universities and colleges [3].

Motivated by the above discussions, in this paper, the PDCA cycle will be applied to analyze the antecedents of teaching quality, and we intend to explore the underlying mechanism of PDCA cycle in improving teaching quality from the motivation theory perspective. We also will identify the moderators and mediators affecting each stage of the

PDCA cycle and propose our hypotheses. Drawing from the goal setting theory in motivation theory, our hypotheses are proposed. The third year colleague students majoring in Computer Science from the Department of Computer Science, Beijing University of Posts and Telecommunications, were recruited and participated in the "Intelligent Management" course, which serves as an illustration.

II. PRINCIPLE OF PDCA CYCLE

The PDCA cycle is a well-known management methodology that was made popular in the field of quality control by Dr. Edwards Deming [6], the father of modern quality control. Its principle is to repeat the four steps of Plan, Do, Check, and Action, on a work project until its output reaches its objective. This management methodology can be applied to any business process improvement as well as education quality improvement.

The Implementation Steps of the PDCA Cycle in the "Intelligent Management" Course

In this section, we will give the integral implementation steps of PDCA cycle in the "Intelligent Management" course for Computer Science students from the Department of Computer Science, Beijing University of Posts and Telecommunications. The steps are given as follows:

The first stage: Plan, is to identify the target and decide what to do to accomplish the target. This stage is divided into the following four steps:

Step 1: analyze current situation and find out the existing problems (including both the teacher and students participated in the "Intelligent Management" course,

respectively);

Step 2: analyze the various reasons or influential factors of the existing problems;

Step 3: find out the main reasons or influential factors;

Step 4: develop countermeasures, protocol measures of management and technology organization for the main reasons, and put forward planning and expected effect.

It should be pointed out that, in this stage, the students will be asked to write a plan for their future study in the "Intelligent Management" course, and the teacher will evaluate their plans.

Step 5: Do, is to implement the relevant tasks and assignments in the "Intelligent Management" course such as those tasks according to the plan, targets and measures formulated in the first stage.

Step 6: Check, is to compare the results of the implementation with the requirements of the plan, and check if the execution and implementation of the plan achieve the desired targets.

The fourth stage: Action. This stage is divided into two steps:

Step 7: draw lessons from the above cycle;

Step 8: summarize the successful experiences and give awards to the students who attain their plans perfectly, meanwhile, finding out the unsolved disuses in this cycle, and shifting them to the next cycle.

Fig. 1 shows the completed implementation steps of PDCA cycle in the "Intelligent Management" course.
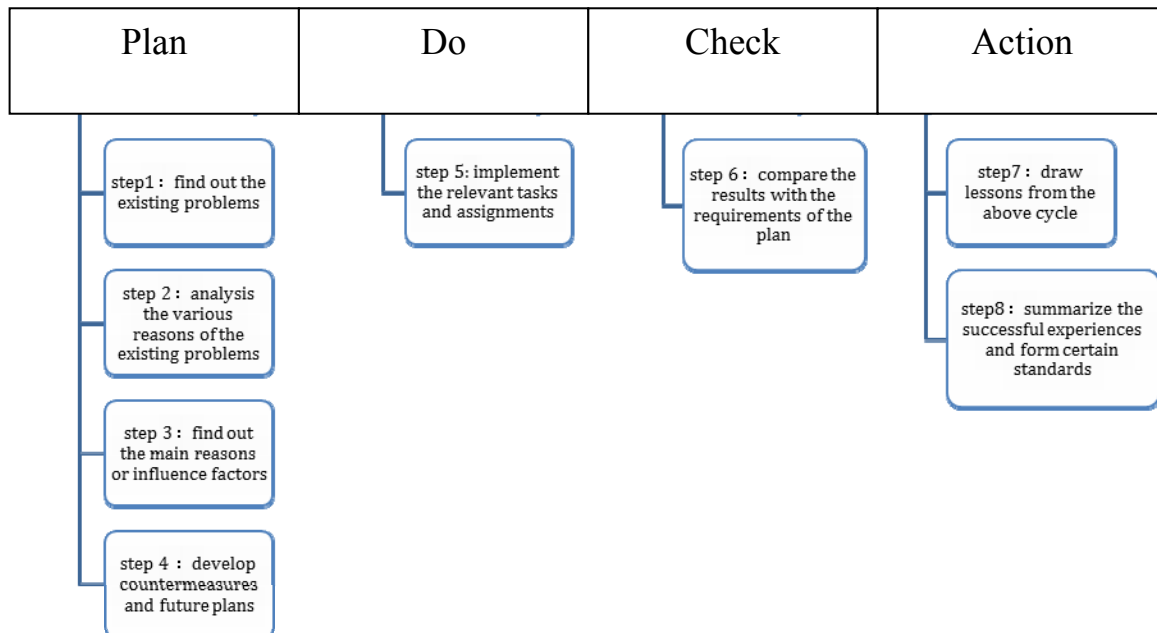

Fig.1 The Implementation Steps of PDCA Cycle

III. THEORETICAL FOUNDATION AND HYPOTHESES

In this section, we will demonstrate that the moderators and mediators influence each stage of the PDCA cycle and propose our hypotheses. Explanations will be provided to show the rationality of our hypotheses from the goal setting theory of motivation theory perspective.

In the first stage "plan", we aim to investigate the current situation of the teacher and students in the "Intelligent Management" course by questionnaire or other approaches. We will find out all the factors affecting the teaching quality. Moreover, we will conduct further analysis to identify which factors are the main influential factors. After identifying the main influential factors, improvement targets and measures for the teacher and students in "Intelligent Management" course have been ensured in the first stage. The students will implement the plans for themselves in the "Intelligent Management" course and access into the second stage "do".

In the third stage "check", the teacher will also check the effects of the students both by their performance in classroom and in their final exam. In the last stage "action", the teacher will give rewards to the students who accomplish their plans successfully and we will pinpoint some unsolved problems for both the teacher and students, and these problems will be further solved in the next cycle.

The PDCA cycle will last 3 months (from September till November). Based on the above discussions, the Hypothesis 1 and Hypothesis 2 will be firstly addressed, which illustrate the goal commitment and task complexity can be seen as moderators to the relationship between the first stage "Plan" and the second stage "Do".

Hypothesis 1: The goal commitment will play a role as the moderator to the relationship between the first stage "Plan" and the second stage "Do".

In the second stage "Do", students study to achieve the goals they set for themselves. As a component of the major process theories of motivation, goal setting theory suggests that individuals are motivated to reach set goals. It also requires that the goals set should be specific.

Suggested by the goal theory, goal commitment is defined as the intention to devote efforts toward the goal accomplishment, persistence in pursuing the goal over time, and unwillingness to lower or abandon that goal. Furthermore, commitment is maximized when goals are difficult. It is the goal commitment which plays an important role for us to understand the relationship between goals and performance. The goal performance relationship becomes stronger when people are committed to their goals [13].

Goal commitment can be enhanced by making a public commitment as well as leaders' support and encouragement. In field settings and laboratory settings, the supervisor's legitimate authority to assign goals creates demand characteristics [16].

According to the above analysis, we can infer that students with higher goal commitment will spend more efforts to achieve their goals. Therefore, the goal commitment may play a role as the moderator to the relationship between the first stage "Plan" and the second stage "Do".

Hypothesis 2: The task complexity will play a role as the moderator to the relationship between the first stage "Plan" and the second stage "Do".

In the second stage "Do", students study to achieve the goals they set for themselves. As the task complexity increases, higher-level skills and strategies have been acquired. The effect size for goal setting is smaller on complex than on simple tasks because people vary significantly in their ability to discover appropriate task strategies.

Meta-analyses were constructed using the procedures outlined by Wood R [19]. Their procedures examined the degree to which correlation differences across studies could be accounted for by statistical artifacts (e.g., sampling error and unreliability) and allowed for the correction of these conditions to obtain the true population correlations. Meta-analyses have revealed goal difficulty effect sizes of 0.48 for the most complex tasks versus 0.67 for the least complex tasks. For specific difficult goals versus a goal to do one's best, the effect size was 0.41 for the most complex tasks versus 0.77 for the least complex tasks.

Since people use a greater variety of strategies on complex tasks than on easy tasks, measures of task strategy often correlate higher with performance than do measures of goal difficulty. In addition, there are often goal-strategy interactions, with goal effects strongest when effective strategies are used [16].

Under the above analysis, we can infer that the higher task complexity will encourage students to discover appropriate task strategies and spend more efforts to achieve their goals. Hence, the task complexity can play a role as the moderator to the relationship between the first stage "Plan" and the second stage "Do".

Next, the following hypothesis will be given, which shows the teacher's comments to the students' performance can be act as a mediator between the teacher's action and the students' performance, and can help the students have a better performance in the next cycle.

Hypothesis 3: In the last stage "Action", the teacher will make comments on the students' performance, by giving them approvals or denials. This can strengthen the students' academic efficacy, which acts as a mediator between the teacher's action and the students' performance, and can help the students have a better performance in the next cycle.

It should be pointed out that self-efficacy enhances goal commitment [16]. Leaders can foster the self-efficacy of their subordinates by ensuring adequate training, role modeling and persuasive communication [20].

In this stage, we will take a look at the students' learning effects by asking them to participate in a midterm

examination and hand in a project report to consolidate the improvement efforts and solve the unaddressed problems. If the goals are not met, students will draw lessons from the above cycle. When goals are met, the teacher will give rewards to students who perform well and share best practices in both formal and informal settings. In this way, students' academic efficacy will be improved so that they will use what they learned to plan new improvements, beginning the cycle again.

At last, the Hypothesis 4 will be given, which shows each stage in the PDCA cycle is essential to improve the students' learning effect.

Hypothesis 4: Each stage in the PDCA cycle is essential to improve the students' learning effect, which influence each other and play a role together.

Education leaders have begun to recognize the potential for PDCA cycle applied to educational organizations [10, 15]. The teaching quality is improved by continually using the PDCA circulation [23]. Therefore, the plan is the premise of the teaching quality improvement, the implementation and the inspection method is the guarantee, and the action is the indispensable.

Consequently, we believe that PDCA cycle will be useful in improving the teaching quality and the students' learning effect. The students' performance in the PDCA group will display a significant difference from the non-PDCA group.

Based on Hypothesis 1-Hypothesis 4, Fig. 2 shows the moderators and mediators which affect each stage of the PDCA cycle.
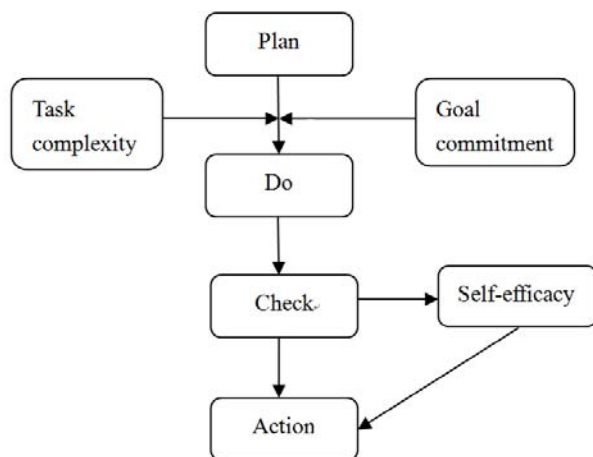

Fig.2 The Moderators and Mediators Affecting Each Stage of the PDCA Cycle

IV. METHOD

A. Sample and Procedures

200 colleague students were recruited in this study. They are the third year colleague students from the Department of Computer Science, Beijing University of Posts and Telecommunications, majoring in Computer Science. The sample includes 140 Male students and 60 female students.

Their age is among 20-22 years old (average age 21). Students are randomly assigned into two groups: PDCA based study group (n=98) and non-PDCA based study group (n=102). Random number table method was used to divide the students into 2 groups. We will study the application of PDCA method and evaluate the performance results for the students.

For the PDCA based study group, we applied the PDCA method in the management for the student course study. In contrast, for the non-PDCA group, we applied the traditional teaching method.

B. Measures

Task performance: The PDCA cycle will last 3 months (from September till November). By the end of November, we will carry on an evaluation test for the two group students. The evaluation criterion will be the results (scores) of final exam and project reports of the two group students. SPSS software is applied to analyze data of the experiment. The scores for two groups are represented by mean±standard deviation. We conduct paired T test for the comparison of the means of the two groups. P≤0.05 means there is significant difference between two groups. If the average score of the students in the PDCA group is significantly higher than the non-PDCA group, we can safely draw a conclusion that PDCA cycle is useful in improving teaching quality.

Goal commitment: The definition of goal commitment is "one's determination to reach a goal". This will be adopted from the HWK Scale (which is a Goal Commitment Items developed by Hollenbeck J, Williams C and Klein H [8]), a 9-item 5-point Likert response scale (1 = not at all, 2 = a little, 3 = somewhat, 4 = mostly, 5 = very well). The HWK scale, shown in Fig 3, was first developed to define and measure goal commitment in the goal setting theory. Summing the responses on the nine indexes to attain a goal commitment index resulted in scores ranging from 0 to 5, with high scores indicating greater goal commitment.

We posit that goal commitment may moderate the relationship between the first stage "Plan" and the second stage "Do" and conduct hierarchical regression analysis to test the results. If so, the interaction terms will indicate a stronger relationship between plan and performance for students with high goal commitment than for students with low goal commitment.

Hollenbeck, Williams, and Klein (1989b) Goal Commitment Items

1. *It's hard to take this goal seriously.* (R)
2. *It's unrealistic for me to expect to reach this goal.* (R)
3. It is quite likely that this goal may need to be revised, depending on how things go. (R)
4. *Quite frankly, I don't care if I achieve this goal or not.* (R)
5. *I am strongly committed to pursuing this goal.*
6. *It wouldn't take much to make me abandon this goal.* (R)
7. *I think this is a good goal to shoot for.*
8. I am willing to put forth a great deal of effort beyond what I'd normally do to achieve this goal.
9. There is not much to be gained by trying to achieve this goal.

Note. Items followed by "R" indicate that the item was reverse-scored before analysis. Italicized items are those included in the recommended five-item scale.

Fig.3 Goal commitment items [14]

Task complexity: As the task complexity increases, higher-level skills are required to achieve the goals. Because people vary greatly in their ability, the effect size for goal setting is smaller on complex than on simple tasks.

Task complexity has been examined in a number of studies from the goal setting literature [19]. In this study, the PDCA group students will participate in quizzes (about 10 minutes) for several times. And they will also participate in a midterm examination. We assume that the task complexity of the quizzes is lower than the midterm examination. Results across performance periods may indicate that specific difficult goals led to lower quantity of performance on a complex task, whereas specific difficult goals led to higher quantity of performance on a simpler version of the task [17].

We will use hierarchical regression analyses to test the results. If task complexity can moderate the relationship between the first stage "Plan" and the second stage "Do", the interaction terms will indicate a stronger relationship between plan and performance for students participate in quizzes than for students participate in the midterm examination.

Plan: In the first stage "plan", after the main affect factors, improvement targets and measures for teacher and students in "Intelligent Management" course have been ensured. Then the students will implement the plans for themselves in "Intelligent Management" course, and the teacher will evaluate each student's plan and give him a score.

Academic diligence: In the second stage "Do", the students' efforts to accomplish their plans will be assessed by using an academic diligence scale, the Diligence Inventory-Higher Education (DI-HE) [11]. It contains forty-eight statements with responses on a 5-point Likert scale. The DI-HE measures "Total Diligence," which includes five scales: Motivation, Concentration and Assimilation, Conformity and Citizenship, Discipline, and Responsibility.

Self-efficacy: This was assessed with the Eccles (1993) School Efficacy Scale, a 6-item 5-point Likert response scale (1 =not at all, 2 =a little, 3 =somewhat, 4 = mostly, 5 = very well). Students responded to items such as:
1. "How well can you get teachers to help you when you get stuck on schoolwork"
2. "How well can you finish the project reports by deadlines"
3. "How well can you live up to the expectations of teachers"
4. "How well can you remember information presented in class and textbooks"

The self efficacy (academic efficacy) questionnaire will be given to the students of the PDCA-group before and after the stage "Action" to check whether the action of teacher (approvals or denials to students) will have a significant effect on the students' self- efficacy. A method of four steps for testing mediation developed by Kenny and his colleagues [2] is used to test the mediating effect of the improved self-efficacy.

If all the four steps are met, then the data are consistent with the hypothesis that variable M completely mediates the X-Y relationship, and if the first three steps are met but the Step 4 is not, then partial mediation is indicated. If self-efficacy is a partial mediator, the relation between action and performance will be significantly smaller when academic efficacy is included but will still be greater than zero.

V. PREDICTIVE RESULTS

Through the analysis of the scores for the two groups, we conclude that the evaluation results for the PDCA based study group may be better than that of the non-PDCA based study group, which may indicate that PDCA based management pattern for colleague students study is a better management method.

Through the hierarchical regression analyses of goal commitment and task complexity, our results suggest that both of them play a role as the moderator to the relationship between the first stage "Plan" and the second stage "Do".

Through Baron and Kenny's four-step method (performed with three regression equations), we may come to the conclusion that self-efficacy acts as a mediator between the fourth stage "action" and the students' final examination performance.

This study adds to the developing literature by emphasizing the importance of understanding the role of PDCA toward the improvement of teaching quality. In addition, this research indicates that the greater goal commitment will enhance the effect of PDCA. Meanwhile, the more task complexity will impact the effect of PDCA. Furthermore, the action of teacher will influence the students' performance by improving the student's self-efficacy.

The contribution of our study is that we apply the product quality management methods to the field of the teaching process. Based on the motivation theory, we study the influence of PDCA cycle for student learning performance. Moreover, we test the moderator and mediator effects in PDCA cycle. We believe that these findings will have practical implications for the design of teaching process to improve the students' performance. Nonetheless, future research may consider examining the causal relationship between these four stages (Plan, Do, Check, Action) and students' performance by using experimental or longitudinal methodologies.

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