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Research on the Teaching Mode of Hydraulics based on PDCA Cycle Theory

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Abstract: The interdisciplinary application requirements and professional knowledge bias pose significant challenges to the teaching of Hydraulics. This paper establishes a problem- and result-oriented PDCA cycle "Hydraulics" course teaching model based on the PDCA cycle theory, elucidates the teaching concept of PDCA cycle "Hydraulics" course, and thoroughly discusses the teaching method and implementation process. Through comparative analysis of teaching results in two sample classes under different modes, it is found that students achieve better results in both process assessment and result assessment under the PDCA cycle teaching mode compared to traditional methods. The research findings can serve as a reference for improving the quality of Hydraulics and related courses.

Keywords: PDCA Cycle Theory; Hydraulics; Teaching Mode; Teaching Quality.

1. Introduction

Hydraulics is a fundamental professional course for water conservancy majors [1-2], extensively applied in traditional fields such as water conservancy, civil engineering, environmental protection, chemical engineering, and machinery. However, the increasingly complex hydraulics problems encountered across various industries due to interdisciplinary practical applications have exacerbated the teaching challenges of Hydraulics. The bias in professional knowledge also presents a significant challenge to its teaching. Simultaneously, rapid iterative development of the era and evolving social demands impose higher requirements on graduates' knowledge reserve, professional quality, and comprehensive abilities in the water conservancy industry. Training water conservancy students who can adapt to fast-paced social development is a critical issue that college teachers need to address.

The PDCA cycle theory has been widely utilized in quality management since its inception. This theory divides the management process into four stages of "planning (P) - execution (D) -inspection (C) -action (A)" [3-5], simplifying complex issues and achieving quality control through standardized process inspection [6]. The PDCA cycle theory is problem- and result-oriented while emphasizing the process of quality control, aligning with the objectives of Hydraulics course learning and re-learning for graduates majoring in water conservancy. This paper primarily explores the application of PDCA cycle theory in the teaching process of Hydraulics."

2. Research on the Teaching Mode of Hydraulics Based on PDCA Cycle Theory

In the PDCA cycle mode, the teaching mode of Hydraulics courses runs through the PDCA cycle control concept and method in the whole teaching process, forming A standardized teaching mode, forming a cycle from teaching plan (P), teaching process implementation (D), teaching effect evaluation (C), teaching-evaluation result feedback (A). From A macro point of view, the realization of teaching process and teaching goal is a big cycle of "course teaching plan (P) -course teaching process implementation (D) -course teaching effect evaluation (C) -course teaching - evaluation result feedback (A)". In detail, the teaching goal is broken down into several small goals, and A relatively independent teaching process is formed. In the teaching process, "chapter teaching plan (P) - chapter teaching process implementation (D) - chapter teaching effect evaluation (C) - chapter teaching - evaluation result feedback (A)" is an embedded small cycle. Under the impetus of the big - small cycle process, the achievement of teaching objectives is achieved.

In the big cycle, based on students' core competence needs, that is, training students to apply hydraulics knowledge to solve practical engineering problems, the teaching objectives of Hydraulics are set, including specific objectives in basic theories, scientific experiments, engineering problems and so on. Then, according to these goals, the author makes detailed teaching plan and teaching content, and firstly carries out the teaching of "three basic theories" of "Hydraulics" course. Then the "three basic theories" are applied to practical engineering problems, such as pressure pipeline flow, open channel flow, weir flow and gate flow, water flow connection and energy dissipation, and the purpose of integration is achieved through the special analysis of engineering problems. In the process of solving problems, it is necessary to use scientific research methods, and finally carry out the teaching of hydraulic model test basis, supplement and improve the shortcomings of the previous research process, and provide scientific research means for students to further study. Then implement the teaching process, in this process, pay attention to the collection of teaching information and conduct systematic evaluation after the completion of the course. Finally, implement teacher-student-employer multi-directional feedback, and revise and improve talent training objectives and teaching objectives of Hydraulics according to the feedback results.

In order to facilitate the realization of course teaching objectives, different sub-objectives are set in different chapter teaching stages. Based on the realization of sub-objectives, chapter teaching plan (P) - chapter teaching process implementation (D) - chapter teaching effect evaluation (C) - chapter teaching - evaluation result feedback (A) is formulated according to local conditions to form a small chapter teaching cycle. The setting of sub-objectives supports the overall objectives of the course. Nested in the big cycle, the four process management constitute an organic whole, simplify complex problems, and in the operation process, timely find and solve problems, promote the teaching quality and students' learning ability to continuously improve, and the formation of students' learning habits will benefit students in college course learning and even in the future learning stage.

2.1. Teaching Plan Arrangement

The teaching plan provides guidance and a framework for teaching, ensuring the organized and systematic presentation of course content. A reasonable teaching plan is crucial for the smooth development of the course and serves as the foundation for achieving teaching objectives. It should take into account students' individual conditions, learning progress, and align teaching activities with course objectives. Following the PDCA cycle theory, the Hydraulics teaching plan is based on core competencies required by water conservancy students. It refines the syllabus, objectives, and derived content while arranging it in a "first simple, then difficult" manner to reflect implementation effects through feedback from enterprises, industries, and graduates.

2.2. Teaching Implementation Process

Hydraulics is a course that studies liquid balance (mainly water) and mechanical movement laws with practical applications [7]. This comprehensive and complex subject presents challenges in comprehension for many students due to its strong theoretical basis and high practical requirements [8]. To address this difficulty in understanding, phased teaching objectives are established: (1) Understanding basic concepts, (2) Mastering basic principles, Solving practical problems. Through phased teachings aligned with these objectives, students can master fundamental content before undergoing assessment to improve subsequent teachings accordingly.

2.3. Teaching Effect Evaluation System

The Hydraulics course demands both theoretical knowledge mastery as well as practical ability demonstration during team discussions or presentations - thus requiring a diversified evaluation system at multiple levels including phased evaluations throughout different stages of learning.

2.4. Evaluation Result Feedback Mechanism

Feedback from diverse multi-level evaluations underpins improvements in both curriculum goals and contents within Hydraulics education - ultimately contributing to successful realization of training targets for water conservancy talents.

3. Research on the Effectiveness of Teaching Hydraulics under Different Models

3.1. Sample Selection

Two classes from 2021 majoring in hydraulic engineering were chosen as research subjects to be taught using different methods. One class (Group E) was taught using PDCA cycle theory while another class (Group F) was taught using traditional methods. After completion of the lessons, assessments were conducted with a summary of evaluations during the teaching process.

Table 1. Two Groups of Students Basic Information Sheets

Serial Number	Sample Size	Gender (Male/Female)	Age
Group E	37	24/13	21
Group F	39	28/11	21

The class of 2021 has not yet graduated, so only the teaching effectiveness in the instructional process is being compared and analyzed. The course of Hydraulics is divided into three stages: understanding basic concepts, mastering basic principles, and solving practical problems. In these stages, four aspects including homework, sub-project assessment, comprehensive project assessment, and theory examination are carried out respectively. According to the "Hydraulics" textbook, the stage of understanding basic concepts involves one chapter with homework and sub-topics assessed once. The stage of mastering basic principles involves two chapters with homework and sub-topics assessed twice each. The stage of solving practical problems involves six chapters with homework and sub-topics assessed six times each. At the end of the course, comprehensive assessment and theory examination will be conducted.

3.2. Comparative Analysis

Table 2. Statistical table of the 1st homework and sub-project assessment (understanding basic concepts stage)

Serial Number	assessment	understanding basic concepts stage			
		1st homework		1st sub-project	
		Number of student	Proportion (%)	Number of student	Proportion (%)
Group E	A	15	40.54	8	21.62
	B	18	48.65	24	64.86
	C	4	10.81	5	13.51
Group F	A	16	41.03	9	23.08
	B	20	51.28	27	69.23
	C	3	7.69	3	7.69

The data in Table 2 indicates a slight disparity between the performance of students from two classes in their initial engagement with the Hydraulics course. In Group E and Group F, 15 (40.54%) and 16 (41.03%) students respectively achieved an A grade in the 1st assignment and sub-topic, while 8 (21.62%) and 9 (23.08%) students did so for Group E and Group F. Furthermore, 18 (48.65%) and 20 (51.28%) students from each group received a B grade, with 24 (64.86%) and 27 (69.23%) achieving this in Group E and Group F respectively for the same tasks. The number of students obtaining a C grade was also higher in Group F compared to Group E, indicating that the academic foundation of students in Group F may be relatively stronger than that of those in Group E.

Table 3. Statistical table of the 2nd to 3rd homework and sub-project assessment (master the basic principles stage)

Serial	assessment	master the basic principles stage							
		2nd homework		2nd sub-project		3rd homework		3rd sub-project	
		Number	Proportion (%)	Number	Proportion (%)	Number	Proportion (%)	Number	Proportion (%)
Group E	A	10	27.03	9	24.32	12	32.43	12	32.43
	B	22	59.46	24	64.86	21	56.76	24	64.86
	C	5	13.51	4	10.81	4	10.81	1	2.70
Group F	A	8	20.51	8	20.51	9	23.08	7	17.95
	B	20	51.28	23	58.97	20	51.28	27	69.23
	C	11	28.21	8	20.51	10	25.64	5	12.82

Table 4. Statistical table of the 4th to 5th homework and sub-project assessment (stage of solving practical problems)

Serial	assessment	solving practical problems stage							
		4th homework		4th sub-project		5th homework		5th sub-project	
		number	proportion (%)	number	proportion(%)	number	proportion(%)	number	proportion(%)
Group E	A	12	32.43	11	29.73	14	37.84	9	24.32
	B	24	64.86	24	64.86	22	59.46	26	70.27
	C	1	2.7	2	5.41	0	0	2	5.41
Group F	A	10	25.64	7	17.95	9	23.08	6	15.38
	B	23	58.97	25	64.1	26	66.67	26	66.67
	C	6	15.38	7	17.95	4	10.26	5	12.82

Table 5. Statistical table of the 6th to 7th homework and sub-topics assessment (solving practical problems)

Serial	assessment	solving practical problems stage							
		6th homework		6th sub-topics		7th homework		7th sub-topics	
		number	proportion(%)	number	proportion(%)	number	proportion(%)	number	proportion(%)
Group E	A	15	40.54	12	32.43	16	43.24	10	27.03
	B	18	48.65	23	62.16	21	56.76	25	67.57
	C	4	10.81	2	5.41	0	0	2	5.41
Group F	A	4	10.26	6	15.38	10	25.64	6	15.38
	B	23	58.97	27	69.23	21	53.85	24	61.54
	C	12	30.77	6	15.38	8	20.51	9	23.08

Table 6. Statistical table of the 8th to 9th homework and sub-topics assessment (solving practical problems)

Serial	assessment	solving practical problems stage							
		8th homework		8th sub-topics		9th homework		9th sub-topics	
		Number	proportion(%)	Number	proportion(%)	Number	proportion(%)	Number	proportion(%)
Group E	A	15	40.54	10	27.03	16	43.24	13	35.14
	B	20	54.05	24	64.86	20	54.05	24	64.86
	C	2	5.41	3	8.11	1	2.7	0	0
Group F	A	9	23.08	4	10.26	8	20.51	6	15.38
	B	21	53.85	26	66.67	26	66.67	25	64.1
	C	9	23.08	9	23.08	5	12.82	8	20.51

The data from Table 3 to Table 6 indicates that in Group E, 10 and 9 students achieved an A grade in the 2nd homework and sub-project, accounting for 27.03% and 24.32% respectively. The number of students who scored a B was 22 and 24, representing 59.46% and 64.86% respectively. In Group F, the percentages of students achieving an A grade in the 2nd homework and sub-project were both at 20.51%, with the numbers of students scoring a B being at 51.28% and 58.97%. For the 9th homework and sub-topics, Group E had higher percentages of students achieving an A grade compared to Group F (43.42% vs.20 .51%, 35 .14 %vs15 .38%).

Table 7. Statistical table of the 2nd to 9th homework assessment

Serial	assessment	2nd	3rd	4th	5th	6th	7th	8th	9th	Total times	Proportion (%)
Group E	A	10	12	12	14	15	16	15	16	110	33.03
	B	22	21	24	22	18	21	20	20	168	50.45
	C	5	4	1	0	4	0	2	1	17	5.11
Group F	A	8	9	10	9	4	10	9	8	67	19.09
	B	20	20	23	26	23	21	21	26	180	51.28
	C	11	10	6	4	12	8	9	5	65	18.52

Furthermore, it is evident that with the implementation of the PDCA cycle "Hydraulics" course teaching mode, there has been significant improvement in learning outcomes for students in Group E compared to those in Group F.

Table 8. Statistical table of the 2nd to 9th sub-topic assessment

Serial	assessment	2nd	3rd	4th	5th	6th	7th	8th	9th	Total times	proportion(%)
Group E	A	9	12	11	9	12	10	10	13	86	25.83
	B	24	24	24	26	23	25	24	24	194	58.26
	C	4	1	2	2	2	2	3	0	16	4.80
Group F	A	8	7	7	6	6	6	4	6	50	14.25
	B	23	27	25	26	27	24	26	25	203	57.83
	C	8	5	7	5	6	9	9	8	57	16.24

Table 7 and Table 8 show the statistical table of the assessment of the 2nd to 9th assignments and sub-projects. It can be seen from the chart that the number of A, B and C in the 2nd to 9th assignments of Group E is 110, 168 and 17, respectively. They accounted for 33.03%, 50.45% and 5.11% respectively. The ABCs of the 2nd to 9th operations in Group F were 67, 180 and 65, accounting for 19.09%, 51.28% and 18.52%, respectively. The subjects A, B and C of group E were 86, 194 and 16, accounting for 25.83%, 58.26% and 4.80%, respectively. The A, B and C subjects of the 2nd to 9th sub-subjects in Group F were 50, 203 and 57, accounting for 14.25%, 57.83% and 16.24%, respectively. On the whole, the number and proportion of students in group E who get A are more than those in Group F, and the number and proportion of students who get C are far less than those in Group F. Through the PDCA cycle of "Hydraulics" course teaching mode, students' passive learning is changed into active learning, which effectively improves students' learning enthusiasm and can achieve better results. At the same time, Table 9 also reflects this concept. In the comprehensive subject and theory exams, the number and proportion of students in Group E who got A are higher than those in Group F, while the number and proportion of students in Group F who got C are much lower.

Table 9. Statistical table of comprehensive subject assessment and theoretical examination assessment

Serial	assessment	Final assessment			
		comprehensive subject		theoretical examination	
		number	Proportion (%)	number	Proportion (%)
Group E	A	12	32.43	13	35.14
	B	23	62.16	23	62.16
	C	2	5.41	1	2.70
Group F	A	4	10.26	6	15.38
	B	25	64.10	27	69.23
	C	10	25.64	6	15.38

4. Conclusion

With the progress of society, the hydraulics problems encountered in various industries are becoming more and more complex. The interdisciplinary application requirements have intensified the difficulty of the teaching of Hydraulics, and the bias of professional knowledge has also brought great challenges to the teaching of Hydraulics. Based on the PDCA cycle theory, this paper constructs a problem - and result-oriented PDCA cycle course teaching model of Hydraulics. The concept and method of PDCA cycle runs through the whole teaching process, simplifies complex problems, finds and solves problems in time during operation, and emphasizes the formation of learning habits. According to the teaching results of the two sample classes in different teaching modes, compared with the traditional teaching mode, the students in the PDCA cycle teaching mode of "Hydraulics" can achieve better results in both process assessment and result assessment. The research results can provide reference for the teaching of "Hydraulics" and related courses.

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