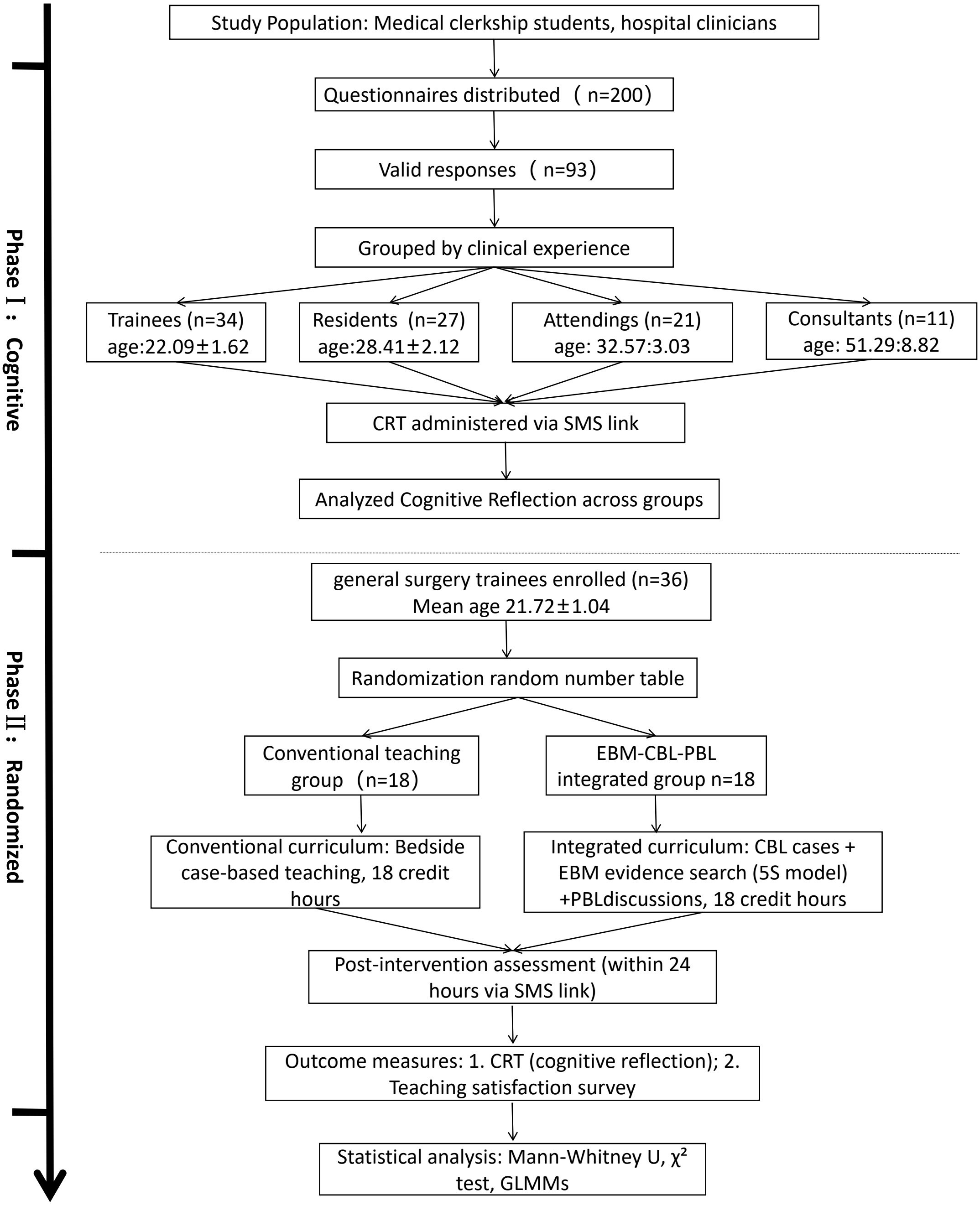
Supplementary Figure 1: Design flowchart



Supplementary Appendix 1: Teaching Design

Design of EBM-CBL-PBL Integrated Teaching Method for General Surgery Interns

1. Teaching Objectives

- Cultivate students' clinical diagnostic thinking, problem-solving skills, and critical thinking.
- Through case analysis and problem discussions, master the diagnosis, differential diagnosis, and treatment principles of common diseases in general surgery.
- Enhance students' evidence-based medicine (EBM) skills, strengthening the integration of clinical practice and research capabilities.

2. Teaching Method Design

2.1 Case Introduction (CBL: Case-Based Learning)

Features: Based on typical cases, real scenarios guide students in learning disease diagnosis and treatment.

Implementation Steps:

a. **Preparation of Typical Cases**: Instructors select representative cases from actual ward patients, ensuring authenticity and completeness.

b. **Case Analysis Content**:

- Medical history collection.
- Clinical manifestations and laboratory tests.
- Preliminary diagnosis, differential diagnosis, and treatment plan.

Example Case:

Case 1: Acute Cholecystitis

- **History**: A middle-aged woman with right upper quadrant colic and fever for 12 hours, with a history of gallstones.
- **Laboratory Tests**: Elevated white blood cell count; ultrasound shows thickened gallbladder wall and multiple gallstones.
- **Discussion Questions**:

① How to differentiate acute cholecystitis from choledocholithiasis?

② What are the indications for conservative treatment versus emergency surgery?

③ What are the preventive measures after cholecystectomy?

2.2 Problem-Driven Learning (PBL: Problem-Based Learning)

Features: Centers on open-ended questions to promote active learning and group collaboration.

Implementation Steps:

a. **Question Design**: Develop guiding questions around the core content of the case to stimulate in-depth thinking.

b. **Group Discussion**: Divide students into groups to research literature, collaborate, and present findings.

Example Open-Ended Questions:

① Compare the advantages and disadvantages of laparoscopic surgery versus traditional open surgery.

② How to assess the severity of acute pancreatitis in patients?

③ What are the preventive measures for postoperative infections in acute appendicitis?

Task Output: Students submit a comprehensive case analysis report and treatment recommendation plan.

2.3 Integration of Evidence-Based Medicine (EBM: Evidence-Based Medicine)

Features: Emphasizes solving clinical problems based on scientific evidence to improve the reliability of clinical decision-making.

Implementation Steps:

a. **Literature Search and Evaluation**: Guide students to use medical databases (e.g., PubMed, Wanfang) to retrieve the latest research.

b. **Application Scenarios**:

① Compare the efficacy and safety of two treatment options.

② Identify the best treatment recommendations for surgical approaches to acute appendicitis (laparoscopic vs. open surgery).

1. **Student Tasks**:

① Read and interpret at least two relevant research papers or guidelines.

② Support their diagnosis and treatment plans with evidence during case discussions.

2.4 Teaching Summary and Feedback

Implementation Steps:

① **Group Presentations**: Each group presents their diagnostic process, treatment strategies, and evidence-based support.

② **Instructor Feedback**: Provide supplementary corrections and critique the strengths and weaknesses of students' answers and reports.

③ **Joint Reflection**: Guide students to summarize academic blind spots and areas for future improvement.

3. Case Library for Implementation

Acute Pancreatitis

Guiding Questions:

1) What are the diagnostic criteria for pancreatitis?

2) How to choose between conservative treatment and surgical intervention?

3) What is the clinical significance of pancreatitis severity scoring?

EBM Task: Review the latest research on early fluid management and guidelines for antibiotic use.

Gastrointestinal Perforation

Guiding Questions:

1) What are the most common causes and clinical manifestations of gastric perforation?

2) How to determine whether a patient requires surgical intervention?

3) What are the common postoperative complications?

EBM Task: Review the latest evidence-based recommendations for abdominal drainage and postoperative antibiotic use.

4. Comprehensive Evaluation

Design a student assessment mechanism to evaluate learning outcomes holistically:

1) **Process Evaluation**: Participation and problem-solving skills during group discussions.
2) **Outcome Evaluation**: Quality of case analysis reports and application of evidence-based literature.

3) **Instructor Feedback**: Provide improvement suggestions based on student performance to further enhance learning outcomes.

Through the integrated teaching methods of CBL, PBL, and EBM, the learning efficiency and clinical practice skills of general surgery interns can be significantly improved, laying a solid foundation for becoming qualified clinical doctors.

Supplementary Figure 2: Cognitive Reflection Test Questionnaires

Cognitive Reflection Test (CRT) Questionnaire

Participant Information

1. Participant Category (Please check the appropriate option):

☐ A. Trainee

☐ B. Resident Physician

☐ C. Attending Physician

☐ D. Consultant-level Physician or above

2. Age: _____ years

3. Gender:

☐ Male

☐ Female

CRT Test Questions

Please read the following questions and write your answers.

Question 1:

A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball.

Question: What is the price of the ball?

Your answer: _____

Question 2:

If it takes 5 machines 5 minutes to make 5 widgets.

Question: how long would it take 100 machines to make 100 widgets?

Your answer: _____

Question 3:

In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake,

Question: how long would it take for the patch to cover half of the lake?

Your answer: _____

Instructions

- Complete the questionnaire independently
- Provide your first intuitive response to each question - no overthinking required
- All responses will be anonymized for research purposes and will not affect your training or work

Thank you for your participation!

Table S1: The answers of three-item Cognitive Reflection Test

Question	Intuitive answer	Correct answer
Q1. A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost?	$0.10	$0.05
Q2. If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?	100 minutes	5 minutes
Q3. A patch of lily pads doubles in size each day. If it takes 48 days to cover the entire lake, how long does it take to cover half of the lake?	24 days	47 days

Note:Analytical responses were defined as correct answers, whereas intuitive responses were defined as incorrect but immediately appealing answers.

Table S2: Data of answers to all three-item Cognitive Reflection Test questionnaire questions by professional level

Answers/data	Trainees (n=34)	Residents (n=27)	Attendings (n=21)	consultant-level (n=14)
CRT-Reflective				
Q1	22 (64.71%)	17 (62.96%)	14 (66.67%)	8 (57.14%)
Q2	24 (70.59%)	21 (77.78%)	17 (80.94%)	9 (64.29%)
Q3	25 (73.53%)	20 (74.07%)	16 (76.19%)	10 (71.42%)
CRT-Intuitive / Incorrect				
Q1	12(35.29%)	10 (37.04%)	7(33.33%)	6(42.86%)
Q2	10 (29.41%)	6 (22.22%)	4(19.06%)	5(35.71%)
Q3	9(26.47%)	7 (25.93%)	5(23.81%)	4(28.58%)
CRT-QAll				
All-Reflective	14 (41.18%)	14 (51.85%)	13 (61.90%)	7 (50.00%)
All-Intuitive	4 (11.76%)	4 (14.81%)	1 (4.76%)	2 (14.29%)
CRT-Mixed	16 (47.06%)	9 (33.33%)	7 (33.34%)	3 (35.71%)

Notes: CRT-Reflective represents analytical thinking answers; CRT-Intuitive represents intuitive thinking answers; Incorrect indicates wrong answers; All-Reflective means that all three CRT questions were answered analytically; All-Intuitive means that all three CRT questions were answered intuitively; CRT-Mixed indicates mixed answer patterns.

Supplementary Figure 3: Teaching Satisfaction Survey Questionnaires

Student Teaching Satisfaction Survey

Participant Information

1. Age: _____ years

2. Gender:

☐ Male

☐ Female

Survey Content

1. Satisfaction with Teaching Methods (Total score: 100)

Please evaluate the current teaching approach:

☐ Very Satisfied (20 points)

☐ Satisfied (16 points)

☐ Neutral (12 points)

☐ Dissatisfied (8 points)

☐ Very Dissatisfied (4 points)

2. Depth of Content Comprehension

How well do you understand the course material?

☐ Very Easy to Understand (20 points)

☐ Relatively Easy (16 points)

☐ Neutral (12 points)

☐ Somewhat Difficult (8 points)

☐ Very Difficult (4 points)

3. Learning Motivation and Interest Level

Does the teaching stimulate your learning interest?

☐ Highly Motivated - Active Learner (20 points)

☐ Moderately Interested - Willing to Learn (16 points)

☐ Neutral - Passive Learner (12 points)

☐ Limited Interest - Rarely Active (8 points)

☐ No Interest - Never Active (4 points)

4. Teacher-Student Interaction and Classroom Atmosphere

(1) How often do you interact with instructors (asking questions/expressing opinions)?

☐ Frequently (10 points)

☐ Occasionally (8 points)

☐ Rarely (4 points)

☐ Never (2 points)

(2) How would you describe the classroom atmosphere?

☐ Very Lively (10 points)

☐ Moderately Active (8 points)

☐ Neutral (6 points)

☐ Somewhat Dull (4 points)

☐ Very Dull (2 points)

5. Future Teaching Method Improvements

(1) Would you like to continue with the current teaching methods?

☐ Strongly Desire (2 points)

☐ Moderately Desire (4 points)

☐ Neutral (6 points)

☐ Slightly Oppose (8 points)

☐ Strongly Oppose (10 points)

Table S3: Data of answers to all three-item Cognitive Reflection Test questionnaire questions and Satisfaction questionnaire Score

Answers/data	Traditional (n=18)	EBM-CBL-PBL (n=18)
CRT-Reflective		
Q1	12 (66.67%)	15 (83.33%)
Q2	9 (50.00%)	14 (77.78%)
Q3	10 (55.56%)	15 (83.33%)
CRT-Intuitive / Incorrect Teaching Satisfaction Survey		
Q1	6 (33.33%)	3 (16.67%)
Q2	9 (50.00%)	4 (22.22%)
Q3	8 (44.44%)	3 (16.67%)
CRT-QAll		
All-Reflective	8 (44.4%)	11 (61.1%)
All-Intuitive	4 (22.2%)	3 (16.7%)
CRT-Mixed	6 (33.3%)	4 (22.2%)
Teaching Satisfaction Survey		
Satisfaction Score	69.0 (62.0-72.0)	74.0 (71.5-78.0)

Notes: CRT-Reflective represents analytical thinking answers; CRT-Intuitive represents intuitive thinking answers; Incorrect indicates wrong answers; All-Reflective means that all three CRT questions were answered analytically; All-Intuitive means that all three CRT questions were answered intuitively; CRT-Mixed indicates mixed answer patterns.