Clinical Trial Protocol
Iranian Registry of Clinical Trials

08 Nov 2026

Medical Students’ Cognitive Processing of Pre-Study Stimuli in a Flipped Classroom Environment And Determining Their Structural Relationships: A Mixed-Methods Study

Protocol summary

Study aim

General Objective: To determine the cognitive processing of medical students when exposed to pre-study processing stimuli in the context of a flipped classroom and to determine their structural relationships.

Design

A controlled clinical trial with parallel groups, single-blind, randomized by the color card method into three intervention groups and one control group

Settings and conduct

At Tehran University of Medical Sciences, the control group will receive only the usual content, and in the case of the intervention groups, the three targeted interventions will be carried out in the pre-class phase of the anatomy unit's kidney block using the flipped classroom method

Participants/Inclusion and exclusion criteria

Second-semester general medicine students at Tehran University of Medical Sciences Inclusion Criteria Second-year medical students at Tehran University of Medical Sciences will be included in the study if they meet the following conditions: • Choosing an official unit in the anatomy course (renal block) Renal block in the semester under study • No previous history of passing this educational block • Informed consent to participate in the study • Active access to the university's e-learning system (Navid) Exclusion Criteria Students who meet any of the following conditions will not be included in the study before random assignment: • Unwillingness to participate or failure to provide informed consent • Lack of stable access to the university's e-learning system • Absence from the initial research briefing

Intervention groups

Group A Guided Reflection Activity (One Minute Paper) Group B Crossword Puzzle Design Activity Group C Interactive Quiz Answers

Main outcome variables

• Pre-class readiness • Immediate retrieval performance • Spaced retrieval performance • Forgetting rate • Metacognitive accuracy

General information

Reason for update

Acronym

IRCT registration information

IRCT registration number: **IRCT20260905070919N1**
Registration date: **2026-10-02, 1405/07/10**
Registration timing: **prospective**

Last update: **2026-10-02, 1405/07/10**
Update count: **0**

Registration date

2026-10-02, 1405/07/10

Registrant information

Name

Maryam Shiri

Name of organization / entity

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Iran (Islamic Republic of)

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Recruitment status

Not yet recruiting

Funding source

Expected recruitment start date

2026-12-26, 1405/10/05

Expected recruitment end date

2027-01-16, 1405/10/26

Actual recruitment start date

empty

Actual recruitment end date
empty
Trial completion date
empty

Scientific title
Medical Students’ Cognitive Processing of Pre-Study Stimuli in a Flipped Classroom Environment And Determining Their Structural Relationships: A Mixed-Methods Study

Public title
Medical Students’ Cognitive Processing of Pre-Study Stimuli in a Flipped Classroom Environment And Determining Their Structural Relationships: A Mixed-Methods Study
Purpose
Education/Guidance
Inclusion/Exclusion criteria
Inclusion criteria:
Second-year medical students at Tehran University of Medical Sciences will be enrolled in the study if they meet the following criteria: Official registration for the Anatomy course (Renal Block) during the semester under study No previous completion of this educational block Provision of informed consent to participate in the study Active access to the university’s electronic learning management system (Navid)
Exclusion criteria:
Unwillingness to participate or failure to provide informed consent Lack of stable access to the university’s electronic learning management system Absence from the initial study orientation session
Age
No age limit
Gender
Both

Phase
N/A
Groups that have been masked

- Outcome assessor
- Data analyser

Sample size
Target sample size: **80**
Randomization (investigator's opinion)
Randomized
Randomization description
Following the identification of eligible participants and obtaining informed consent, participants will be allocated to the intervention and control groups using a randomization method based on colored cards. For this purpose, four card colors will be assigned to the respective groups (red, yellow, blue, and green). During the first session, an equal number of cards in each of the four colors, corresponding to the total number of students in the class, will be placed on a table. As the students will be unaware of the group assignments, each student will select one of the colored cards, and their name and the color of the selected card will be recorded. Accordingly, they will be allocated to the four intervention and control groups, and no further information regarding the group assignments will be provided to them until the intervention begins. Although the researcher must be aware of the group assignments for the purpose of study management, to prevent allocation bias and ensure observer blinding, the researcher responsible for data analysis and the examiner responsible for scoring the tests will remain blinded to the participants’ group assignments (assessor blinding). Each student will remain in the assigned group throughout all intervention sessions. To control for bias arising from differences in the scientific content of the sessions, the subtopics will be matched in terms of volume, complexity, and prerequisite knowledge; a pre-class readiness test will be administered at the beginning of each session; and the variable “session/content” will be included as a repeated factor in the statistical analyses.
Blinding (investigator's opinion)
Single blinded
Blinding description
Due to the nature of the educational interventions, double-blinding is not feasible. The students and instructor will be aware of the group assignments, which may influence their behavior and performance; this will be acknowledged as a limitation of the study. To address this limitation, data analyst blinding will be implemented. The data analyst will be unaware of the group assignments, and the data will be provided using numerical codes. The use of an active control group (rather than no intervention) to reduce expectancy effects, as well as the explicit documentation and reporting of the blinding status in the final report, are additional strategies for addressing this limitation.
Placebo
Not used
Assignment
Parallel
Other design features

Secondary Ids

empty

Ethics committees

1

Ethics committee
Name of ethics committee
Research Ethics Committee, Faculty of Medicine, Tehran University of Medical Sciences
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Approval date
2026-07-25, 1405/05/03

Ethics committee reference number
IR.TUMS.MEDICINE.REC.1405.237

Health conditions studied

1

Description of health condition studied
پردازش شناختی
ICD-10 code
ICD-10 code description

Primary outcomes

1

Description
The status of students' cognitive processing will be measured based on the following criteria: • Quantitative and qualitative indicators of content recall • Pre-class readiness • Immediate retrieval performance • Spaced retrieval performance • Forgetting rate • Metacognitive accuracy
Timepoint
1. Pre-class preparation and immediate retrieval: At the beginning of the flipped class session, through the pre-class preparation test2. Content review assignment: At the beginning of each flipped class session 3. Content review assignment: At the end of each flipped class session 4. Spaced learning: At the end of the academic year and simultaneously with the official final exam of the anatomy course (renal block), so that the scores related to the questions related to the topics of the intervention sessions will be used as an indicator of long-term retention of knowledge in the research analysis.5. Metacognitive accuracy at the end of the semester after assessing students' performance on the final exam 6. Forgetting rate at the end of the semester after assessing students' performance on the final exam This multi-temporal design allows for the examination of the effects of interventions on different stages of information processing, including encoding, consolidation, and retrieval of knowledge
Method of measurement
In this study, cognitive processing as a multidimensional construct is calculated by combining and scoring the following indicators for each student: Encoding depth index: cognitive creativity score (based on the number of innovative connections and structured organization of concepts in the content retrieval task). Monitoring accuracy index: metacognitive accuracy score (calculated through Spearman correlation and calibration error between confidence score and actual performance). Retrieval efficiency index: knowledge development score (based on the number of key concepts identified, accuracy in numbering, and completeness of content coverage in retrieval, which indicates success in the active retrieval process). Readiness is defined as the score students take on the Readiness Assessment Test (RAT). This test consists of 4 to 6 multiple-choice questions with a difficulty level similar to that of the end-of-term exam, administered in writing at the beginning of each class session (after the pre-study phase). The test questions assess students' understanding of the pre-class content (including videos or educational texts) in the anatomy course (renal block). Each question carries a score, and the average RAT scores over the semester are used as an overall indicator of "readiness" for statistical analysis. This test will serve a dual purpose, assessing students' readiness as well as their immediate retrieval performance. Immediate retrieval performance refers to the student's performance on the cognitive readiness test that will be administered at the beginning of class sessions. In order to prevent increased cognitive and work load on students, the readiness test and immediate performance test will be administered as a single test at the beginning of class sessions. A similar retrieval test (with the same questions or meaningful equivalents) is administered at the end of the academic semester. The student's score on the flipped classroom sections is the spaced retrieval performance. The forgetting rate is calculated based on the principles of the founder of memory psychology, Ernst Ebbinghaus, and inspired by modern research on spaced retrieval and the method of calculating forgetting rates in the Wickstead (1992) study (95). This index is defined as a quantitative measure of the rate of learning loss over time. The forgetting rate for each participant is calculated by subtracting the spaced retrieval test score from the immediate retrieval test score and dividing the result by the immediate test score (multiplying by 100). In this formula, the immediate retrieval score indicates the amount of initial learning and the spaced retrieval score indicates the amount of knowledge retained in the long term. This index is used as a measure of the stability of learning and the persistence of knowledge in long-term memory.The lower the forgetting rate in the intervention groups compared to the control group, the higher the effectiveness of that intervention in consolidating learning. In this study, the JOL instrument is designed as an item-based instrument. This instrument is self-reported and is such that after each question of the readiness test (immediate retrieval test), the student also answers the following question: "How confident are you that you can answer the question on this topic correctly on the final exam?" Students are asked to record their level of confidence (for example, on a Likert scale of 0 to 2, where 0 is not at all confident, 1 is somewhat confident, and 2 is completely confident). The total score will be the average of the number of responses. In order to measure metacognitive accuracy, two quantitative indicators are used:1. Spearman correlation: It is calculated between confidence scores and actual performance scores to measure the student's ability to distinguish between knowledge and ignorance.2.Calibration error: Calculated as the absolute difference between the mean confidence score and the mean actual performance to assess the student's degree of systematic optimism or pessimism. In the final analysis, a higher score in Spearman's correlation and a lower score in calibration error indicate more favorable metacognitive accuracy. Knowledge development is defined as the score students receive from the content review assignment. In this assignment, students are

asked to write down all the key words or concepts related to the session topic on a sheet of paper and to indicate a specific numbering for each concept (according to the structure provided in the pre-class resources). This assignment is collected from students at the beginning and end of each flipped classroom session. Scoring is done in three areas based on calculating the number of key concepts identified, accuracy in numbering and completeness of session content coverage, conceptual errors, and cognitive creativity (maximum score for each assignment: 10). The scores students receive from this assignment at the beginning and end of class and their averages are calculated, and the average scores for each session throughout the semester are used as an indicator of “knowledge development.”Correction and evaluation are carried out by two independent evaluators and, in case of disagreement, by a third evaluator

Secondary outcomes

empty

Intervention groups

1

Description

Intervention group: Group A must complete a guided reflection activity (one-minute paper) after studying the pre-class content and based on it, before attending the class, and submit the completed activity in the homework section of the Navid system no later than one day before the class. These responses are reviewed by the researcher to confirm the completion of the activity (without grading).The method of doing the activity is as follows: students must answer the following two questions based on the rules of the one-minute paper method:1- "What was the most important thing you learned from this content?"2- "What question remained for you after studying?"In group B, students design a crossword puzzle themselves after studying the pre-class content, and no later than one day before the class, and then solve it and submit the results via the Navid electronic system. The activity will not be graded again.This activity includes:• Selecting at least 8 key anatomical concepts (renal block)• Generating meaningful clues for each concept• Designing a table in which words intersect horizontally and vertically• And solving the table to receive internal feedback on the correctness of the connection between the concepts.In Group C, after studying the pre-class content and up to one day before the class, students participate in an interactive quiz that is uploaded to the Navid system as a short 5-question multiple-choice test. The questions are randomly selected from the question bank related to the session content and the answers are provided immediately with immediate feedback (true / false with a short explanation)

Category

Behavior

Recruitment centers

1

Recruitment center

Name of recruitment center
Faculty of Medicine, Alborz University of Medical Sciences

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Sponsors / Funding sources

1

Sponsor

Name of organization / entity
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Full name of responsible person
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Grant name

Grant code / Reference number

Is the source of funding the same sponsor organization/entity?
Yes

Title of funding source
Tehran University of Medical Sciences

Proportion provided by this source
100

Public or private sector

Public

Domestic or foreign origin

Domestic

Category of foreign source of funding

empty

Country of origin

Type of organization providing the funding

Academic

Person responsible for general inquiries

Contact

Name of organization / entity

Tehran University of Medical Sciences

Full name of responsible person

Maryam Shiri

Position

Student

Latest degree

Master

Other areas of specialty/work

Medical Education

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Sharing plan

Deidentified Individual Participant Data Set (IPD)

No - There is not a plan to make this available

Justification/reason for indecision/not sharing IPD

There is no further information

Study Protocol

Yes - There is a plan to make this available

Statistical Analysis Plan

Yes - There is a plan to make this available

Informed Consent Form

No - There is not a plan to make this available

Clinical Study Report

Yes - There is a plan to make this available

Analytic Code

No - There is not a plan to make this available

Data Dictionary

No - There is not a plan to make this available

Title and more details about the data/document

Article and Thesis

When the data will become available and for how long

permanent

To whom data/document is available

All

Under which criteria data/document could be used

For research and scientific use

From where data/document is obtainable

Maryam Shiri

What processes are involved for a request to access

data/document

Visit the website of the journal where the article is waiting and download the article or send an email requesting the article to: m.shiri@abzums.ac.ir

Comments