

Making foundational-clinical integration visible: an exploratory mixed-methods course evaluation of the BASIC tutorial model

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Abstract

Background

Students in the early years of medical school often acquire foundational knowledge in separate parts. Although they may remember individual facts, many still find it difficult to apply them when working through a clinical case. We developed BASIC, a five-step tutorial built around clinical scenarios, to guide students from retrieval of prior knowledge to mechanism-based explanation.

Methods

BASIC was introduced into a second-year basic science review course in which cardiovascular disease provided the main teaching context. After the course, 33 students and 20 teachers completed anonymous questionnaires. We summarised Likert-domain scores using means and standard deviations and calculated Cronbach's alpha descriptively. Categorical responses and short written comments were coded for recurrent learning difficulties and considered alongside the quantitative results in a joint display.

Results

Students gave their highest rating to knowledge activation and consolidation (mean 4.58, SD 0.49). Clinical scenario-to-mechanism mapping received the lowest student-domain rating (mean 4.11, SD 0.75). Among teachers, course value and perceived transferability received the highest rating (mean 4.44, SD 0.50), whereas observed student learning performance received the lowest (mean 3.76, SD 0.62). The most frequently selected student difficulties were integrating pathology, pathophysiology and pharmacology (16/33, 48.5%) and forgetting foundational knowledge (25/33, 75.8%). Teachers most often selected problem-chain design as an area requiring improvement (10/20, 50.0%). Written comments also drew attention to pharmacology, review scaffolds, pacing and consistency across teachers.

Conclusions

Participants generally viewed BASIC as a workable structure for clinical scenario-integrated basic science review. The evaluation identified the retrieval-to-explanation transition as the point at which further scaffolding may be useful. Objective evaluation in larger, multi-institutional studies is needed to determine its effects on learning and transfer.

Background

Foundational science supports clinical reasoning and later clinical practice, although retaining and applying this knowledge over time remains difficult [1, 2]. Curriculum integration therefore involves more than placing basic and clinical content next to each other; learners must be helped to connect the two cognitively [3–5]. This connection is particularly fragile early in medical training, when students may recognise relevant concepts but struggle to use them together to interpret a clinical case [6].

Clinical scenarios and tutorial discussions can provide a reason to revisit prior knowledge, particularly when the reasoning process is explicitly structured [7]. Recent reviews of clinical reasoning curricula emphasise that reasoning processes should be made explicit through planned instructional activities rather than assumed to emerge from participation in cases [8–10]. For a novice learner, a clinical vignette can require simultaneous cue identification, knowledge retrieval, mechanism mapping, discussion with peers and response to teacher prompts. Cognitive load may therefore increase when the intended reasoning sequence remains implicit [11, 12].

We developed the BASIC tutorial model to provide a visible instructional sequence. BASIC stands for Basic knowledge activation, Analytical mapping, Scenario-integrated learning, Interpretive reasoning, and Consolidation and transfer. A clinical scenario triggers the discussion, but diagnosis is not the primary endpoint. Instead, students move between pathology, pathophysiology and pharmacology and work towards a reusable clinical finding-mechanism-treatment rationale pathway.

Accordingly, we examined students' and teachers' experiences with BASIC and explored where students had difficulty linking foundational knowledge to clinical explanations. The findings were then used to guide revisions to the next iteration of the tutorial. This exploratory course evaluation focused on the feasibility and perceived value of BASIC, as well as areas requiring further curriculum development.

Methods

Study design and setting

This study was an exploratory, convergent mixed-methods course evaluation conducted in a second-year basic science review course at Zhejiang University School of Medicine, China. Quantitative questionnaire data were given priority, while categorical items and brief open-text responses were used to explain the domain-level patterns. The evaluation focused on perceptions, observed learning behaviours and curriculum-design needs; it was not designed as a controlled effectiveness study.

Cardiovascular disease served as the main teaching context. Tutorial threads included progression from hyperlipidaemia to ischaemic heart disease, hypertension to heart failure, and the mechanistic rationale for common therapeutic choices.

The BASIC tutorial model

The five BASIC steps formed the teaching spine (Fig. 1). Students first retrieved prior pathology, pathophysiology and pharmacology knowledge. They then linked symptoms, signs and test findings to underlying mechanisms; reorganised fragmented knowledge within a clinical scenario; used mechanisms to explain clinical change and treatment rationale; and summarised key points for application to new cases.

Teachers used question chains to guide students from clinical cues to mechanisms and then to treatment rationale. The model was designed as a structured and practical instructional framework rather than as a replacement for existing basic science teaching.

Participants and data collection

All students and teachers who participated in the course were invited to complete anonymous post-course questionnaires. Completed questionnaires were available from 33 students and 20 teachers. No directly identifying information was collected.

The student questionnaire contained 30 Likert items, categorical questions and three open-ended questions. It assessed knowledge activation and consolidation, clinical scenario-mechanism mapping, pathology-pathophysiology-pharmacology integration, classroom participation and question guidance, pace and cognitive load, review support, curricular consistency and overall value. The teacher questionnaire contained 23 Likert items, categorical questions and four open-ended questions covering observed student performance, case design and integration, classroom implementation, review support, consistency and perceived course value and transferability. Items were rated from 1 (strongly disagree) to 5 (strongly agree). The student and teacher questionnaires were developed specifically for this study to align with the intended functions of BASIC and the practical decisions the evaluation was intended to inform, following general questionnaire-development principles [13]. They have not been published previously. The complete English-language student and teacher questionnaires are provided in Additional file 1.

Quantitative analysis

Domain scores were calculated as respondent-level means of the items assigned to each domain and are reported as mean and SD. Cronbach's alpha was calculated as a descriptive indicator of internal consistency. Because the student and teacher questionnaires measured different constructs and the sample was small, no inferential comparisons were made between groups or domains. Categorical responses are reported as counts and percentages.

Open-text analysis and mixed-methods integration

Open-ended responses were coded thematically and pragmatically to identify recurrent learning bottlenecks and curriculum-design needs [14]. The coding framework included knowledge decay, pharmacology-related difficulty, mechanism mapping, pace and cognitive load, review scaffolds, and consistency or alignment. Multiple codes could be assigned to a single response. Open-text percentages therefore indicate the proportion of respondents whose comments contained a given signal; they were used descriptively and were not treated as estimates of theme prevalence.

Quantitative domain scores, categorical responses and coded open-text signals were integrated in a joint display to identify convergence and divergence across data sources [15]. The joint display is presented in Table 1.

Table 1
Joint display of quantitative and open-text findings from the BASIC tutorial evaluation

Integrated issue	Quantitative findings	Open-text signal	Integrated interpretation
Knowledge activation and prior knowledge decay	Students: knowledge activation and consolidation 4.58 (0.49; alpha = 0.837). Teachers: observed student learning performance 3.76 (0.62; alpha = 0.875). Categorical item: 25/33 students (75.8%) selected forgetting foundational knowledge as a major learning burden.	Students described the scenarios as a useful way to reconnect previously learned content, while teachers still observed uneven recall during case discussion.	BASIC supported reactivation of prior knowledge, but incomplete retrieval remained an early barrier to case interpretation.
Clinical cue-to-mechanism mapping	Students: clinical scenario-mechanism mapping 4.11 (0.75; alpha = 0.918), the lowest student-domain score; classroom participation and question guidance 4.37 (0.73; alpha = 0.876). Teachers: observed student learning performance 3.76 (0.62).	Comments pointed to difficulty linking symptoms, signs and test findings with underlying mechanisms and then using those mechanisms to explain changes in the case.	The transition from clinical cues to causal explanation was less secure than knowledge retrieval or participation in discussion.
Foundational integration and pharmacology bottleneck	Students: foundational integration 4.40 (0.70; alpha = 0.924). Teachers: case design and interdisciplinary integration 4.22 (0.56; alpha = 0.873). Categorical item: 16/33 students (48.5%) selected integration as the most difficult step.	Treatment choices became difficult when students had to connect drug action and indication with the disease mechanism and the clinical situation.	Positive ratings for integration coexisted with difficulty justifying treatment choices through a mechanism-based explanation.
Pace, cognitive load and review support	Students: pace and cognitive load 4.24 (0.99; alpha = 0.942); key-point signalling and review support 4.35 (0.81; alpha = 0.900). Teachers: classroom implementation, pace and workload 4.21 (0.57; alpha = 0.895).	Participants described difficulty keeping pace when retrieval, cue interpretation and discussion occurred together, and noted the value of clearer summaries and review materials.	Favourable average ratings did not exclude episodes of cognitive overload, particularly when several reasoning tasks had to be managed at once.
Shared teaching logic and alignment	Students: curricular consistency and assessment alignment 4.20 (0.76; alpha = 0.667). Teachers: key-point signalling, review support and	Open comments raised concerns about variation in teaching logic, question chains, emphasis and	Differences in facilitation may reduce consistency across sessions even when the
Values are mean (SD) domain scores on a five-point Likert scale. Alpha denotes Cronbach's alpha within the present sample. Open-text signals are concise analytic summaries of recurrent responses rather than verbatim quotations or prevalence estimates. S and T denote student and teacher questionnaire items, respectively.			

Integrated issue	Quantitative findings	Open-text signal	Integrated interpretation
	consistency 4.16 (0.58; alpha = 0.884). Categorical item: 10/20 teachers (50.0%) selected problem-chain design as an area needing optimisation.	expected depth across facilitators.	overall tutorial structure is shared.
Overall value and perceived transferability	Students: overall value and willingness to recommend 4.38 (0.85; alpha = 0.820). Teachers: course value and perceived transferability 4.44 (0.50; alpha = 0.924).	Students valued the clinical scenarios as a concrete structure for review, and teachers considered the model potentially adaptable to other systems.	Participants perceived the model as useful and adaptable, although this evaluation did not test educational effectiveness or scalability.
Values are mean (SD) domain scores on a five-point Likert scale. Alpha denotes Cronbach's alpha within the present sample. Open-text signals are concise analytic summaries of recurrent responses rather than verbatim quotations or prevalence estimates. S and T denote student and teacher questionnaire items, respectively.			

Use of generative artificial intelligence

During manuscript preparation, the authors used ChatGPT (GPT-5.6 Thinking, OpenAI) solely for English-language editing and refinement. The tool was not used for study design, data analysis, interpretation of results or generation of scientific conclusions. All revised text was reviewed and approved by the authors, who take responsibility for the final manuscript.

Results

Domain-level questionnaire findings

Completed questionnaires were available from 33 students and 20 teachers. Domain-level results are presented in Table 1 and Fig. 2.

Among students, knowledge activation and consolidation had the highest mean score (4.58, SD 0.49). Overall value and willingness to recommend the tutorial also received a high score (mean 4.38, SD 0.85), as did classroom participation and question guidance (mean 4.37, SD 0.73), key-point signalling and review support (mean 4.35, SD 0.81), and foundational integration (mean 4.40, SD 0.70). Scores were lower for pace and cognitive load (mean 4.24, SD 0.99), curricular consistency and assessment alignment (mean 4.20, SD 0.76), and clinical scenario–mechanism mapping (mean 4.11, SD 0.75). The latter was the lowest student-domain score.

Teachers gave the highest score to course value and perceived transferability (mean 4.44, SD 0.50). Case design and interdisciplinary integration (mean 4.22, SD 0.56), classroom implementation, pace and

workload (mean 4.21, SD 0.57), and key-point signalling, review support and consistency (mean 4.16, SD 0.58) received similar ratings. Observed student learning performance had the lowest teacher-domain score (mean 3.76, SD 0.62).

Cronbach's alpha ranged from 0.820 to 0.942 across the student domains, except for curricular consistency and assessment alignment ($\alpha = 0.667$). Values for the teacher domains ranged from 0.873 to 0.924. Given the small sample and the developmental use of the questionnaires, these values were treated as descriptive indicators of internal consistency.

Categorical and open-text findings

In the categorical items, 16 of 33 students (48.5%) selected integration of foundational disciplines as the most difficult step in the tutorial. Forgetting previously learned foundational knowledge was selected by 25 students (75.8%) as a major source of learning burden. Among teachers, problem-chain design was the most frequently selected area requiring improvement (10/20, 50.0%).

Open-text responses provided further context for these findings (Fig. 3). Students described the cardiovascular scenarios as a useful setting for reconnecting previously learned material. At the same time, 27 of 33 students (81.8%) provided comments indicating a need for stronger review scaffolds, and 21 (63.6%) referred to pharmacology-related difficulty. Teacher comments most often concerned mechanism mapping (10/20, 50.0%), pace or workload (8/20, 40.0%), and consistency or alignment across teachers (8/20, 40.0%). Because more than one code could be assigned to a response, percentages for the open-text signals were interpreted descriptively.

Integration of quantitative and open-text findings

Table 1 brings together the domain scores, categorical responses and written comments. Knowledge activation received a high student rating, whereas both student and teacher data indicated greater difficulty when clinical information had to be linked to an underlying mechanism. Pharmacology-related comments showed that the same difficulty arose when students were asked to explain the rationale for treatment choices.

Some learning difficulties were not apparent from the mean domain scores alone. Foundational integration received a relatively high score, yet nearly half of the students selected integration as the most difficult step. Ratings for pace and review support were also generally positive, although written comments described occasions when retrieval, cue interpretation and discussion became difficult to manage at the same time. Across the data sources, the main pattern concerned the retrieval-to-explanation transition: students were more comfortable reactivating prior knowledge than using it to construct a mechanism-based clinical explanation.

Discussion

In this evaluation, BASIC gave tutorial discussion a clearer route from knowledge retrieval to clinical explanation. Its value lay in how the five-step sequence organised reasoning around a clinical scenario, rather than in the scenario alone. This interpretation is consistent with cognitive integration research, which emphasises that foundational and clinical knowledge need to be connected in learners' thinking [4]. Recent instructional studies likewise suggest that clinical scenarios are most useful when paired with an explicit structure for organising reasoning [5, 7]. By locating where this transition became difficult, BASIC also provided a practical way to identify learning bottlenecks.

The retrieval-to-explanation transition was the main challenge identified across the quantitative and open-text findings. Students rated knowledge activation and consolidation highest, whereas clinical scenario-mechanism mapping received the lowest student-domain score. Teachers also rated observed student learning performance lower than course design and perceived value. These patterns suggest that retrieving relevant concepts and reorganising them into a causal explanation are related but distinct cognitive tasks. Foundational science supports reasoning when it provides causal coherence for clinical findings [1, 2], and mechanism-based instruction may help learners apply knowledge beyond familiar examples [16, 17]. Within BASIC, analytical mapping and interpretive reasoning therefore appear to require the greatest scaffolding.

Pharmacology-related reasoning illustrated the same transition. Students could more readily recognise common treatments than explain how a treatment's target, indication and expected effect followed from the underlying disease process. Recent pharmacology education studies have similarly described the difficulty of connecting mechanistic content with clinical application and therapeutic decisions [18, 19]. Reviews of undergraduate clinical reasoning also support explicit instruction in the reasoning process [8–10]. In future BASIC sessions, treatment choices should be discussed alongside mechanism mapping so that students can follow the link from disease mechanism to therapeutic decision.

A clinical scenario alone did not ensure integration. Students had to retrieve prior knowledge, identify relevant cues, discuss mechanisms and respond to teacher prompts within the same session. The scenario appeared to be most useful when it organised fragmented knowledge around a meaningful clinical context. When these tasks were insufficiently supported, cognitive demand could increase. Cognitive load principles suggest that preparatory review, worked prompts and staged complexity can help learners manage such demands [11, 12]. The next course iteration will include brief pre-class retrieval activities, clearer cue-to-mechanism prompts, questions linking treatments with disease mechanisms and planned pauses for consolidation. Shared question chains may also reduce variation across teachers. These changes should be viewed as design hypotheses generated from the present evaluation.

Although cardiovascular disease provided the teaching context, the BASIC sequence is not tied to one organ system. Other integration initiatives have also identified curriculum structure, time and teacher alignment as recurring implementation issues [3, 5]. BASIC may therefore be adaptable to other areas of foundational science review, but this requires testing across topics, teachers and institutions. Later

studies could assess mechanism-based explanation, therapeutic reasoning, cognitive load and consistency of tutorial delivery.

This study has several limitations. It was conducted in a single course at one institution and involved a small number of students and teachers. The findings were based on post-course questionnaires, brief written comments and teacher observations rather than objective measures of learning. The study did not include a comparison group, baseline assessment or delayed evaluation of transfer. The questionnaires were developed for local curriculum evaluation, and Cronbach's alpha was therefore interpreted only as a descriptive indicator of internal consistency. The open-text responses provided less depth than interviews or focus groups, and the consistency of BASIC implementation across teachers was not formally assessed. Future studies should include direct assessment of mechanism-based explanation, delayed transfer tasks, observation of tutorial delivery and comparative or multi-institutional designs.

Conclusions

BASIC provided a practical structure for clinical scenario-integrated foundational science review. This evaluation identified the retrieval-to-explanation transition as a key point requiring further support. Comparative studies should now examine its effects on learning and transfer.

Abbreviations

BASIC

Basic knowledge activation, Analytical mapping, Scenario-integrated learning, Interpretive reasoning, and Consolidation and transfer

SD

standard deviation.

Declarations

Additional files

Additional file 1 (.docx): BASIC Tutorial Evaluation Questionnaires. Complete English-language versions of the anonymous post-course questionnaires for students and teachers.

Ethics approval and consent to participate

Participation was voluntary, and all students and teachers were informed that their responses would be used for educational research. Completion of the anonymous questionnaire was regarded as implied informed consent. No personally identifiable or sensitive information was collected. The study was conducted in accordance with the Declaration of Helsinki. The need for formal ethics review was

assessed by the Ethics Committee of the First Affiliated Hospital, Zhejiang University School of Medicine, which determined that formal ethics approval was not required for this anonymous, minimal-risk educational course evaluation.

Consent for publication

Not applicable. No identifiable personal information is included in this manuscript.

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

YY and YX conceived and designed the study. YY, YZ, SZ and YX contributed to course implementation, data acquisition and interpretation. YY drafted the manuscript. YZ, SZ and YX critically revised the manuscript. All authors read and approved the final manuscript.

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Not applicable.

Availability of data and materials

The de-identified datasets generated and analysed during the current study are available from the corresponding author on reasonable request, subject to institutional requirements.

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Figures

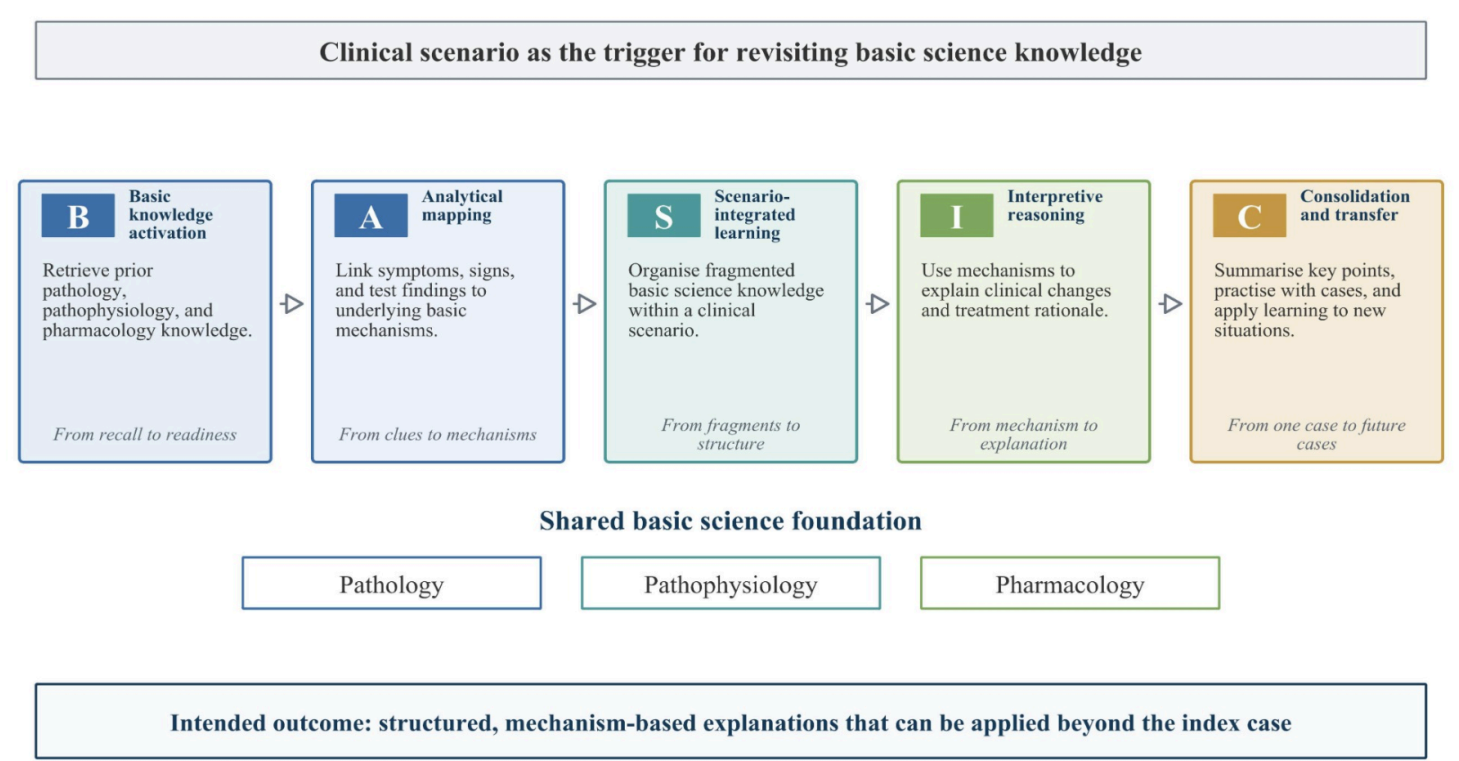


Figure 1

The BASIC model for clinical scenario-integrated foundational science review. A clinical scenario initiates the five-step BASIC sequence: Basic knowledge activation, Analytical mapping, Scenario-integrated learning, Interpretive reasoning, and Consolidation and transfer. The sequence is supported by a shared foundational science base and is intended to help learners construct mechanism-based explanations that can be applied beyond the index case.

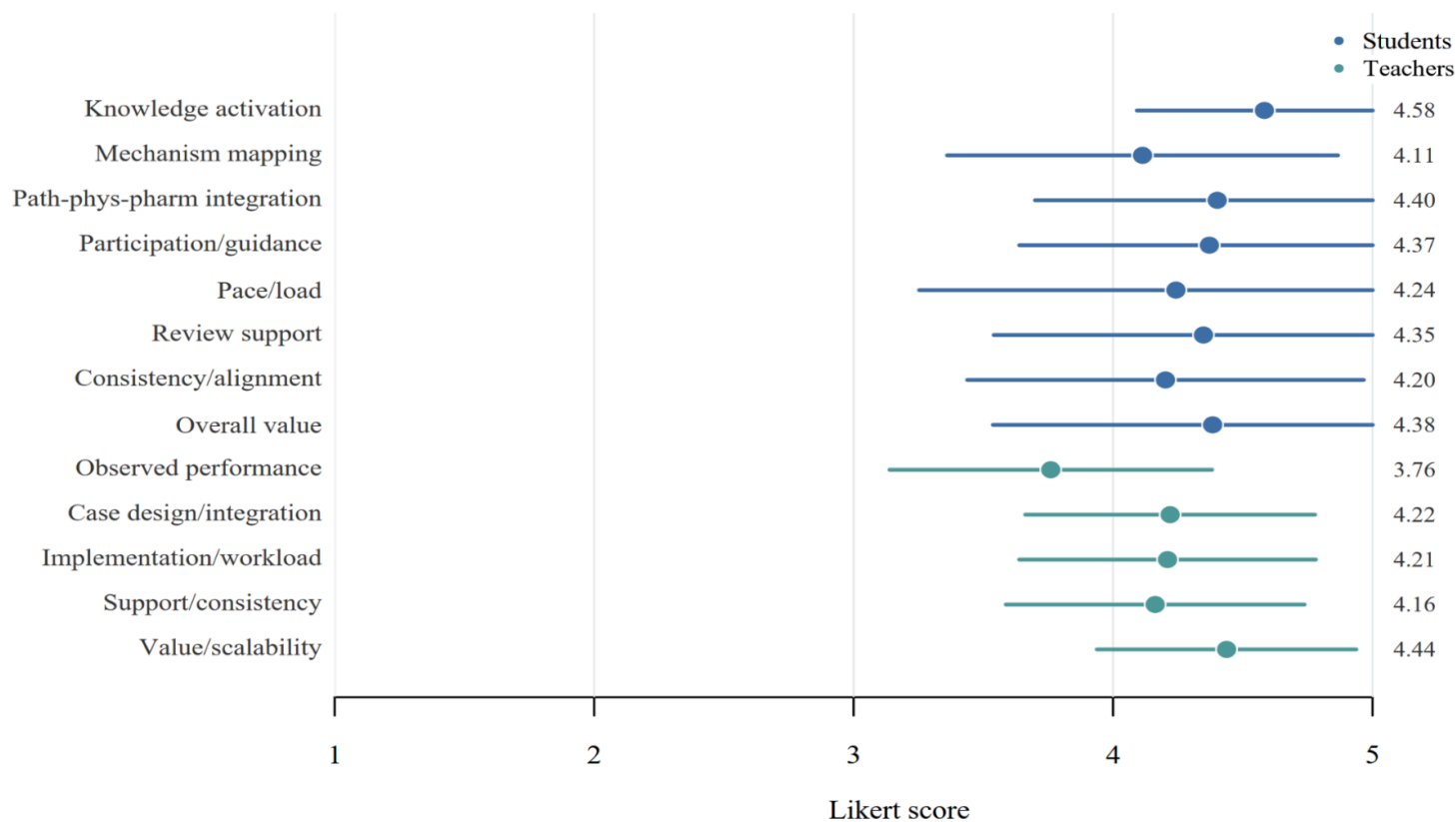


Figure 2

Student and teacher domain scores for the BASIC tutorial. Points indicate mean domain scores, and horizontal lines indicate the corresponding standard deviation ranges clipped to the 1-5 Likert response scale. Student and teacher domains were derived from different questionnaires and represent different constructs; they are shown together for descriptive purposes and should not be interpreted as paired or inferential comparisons.

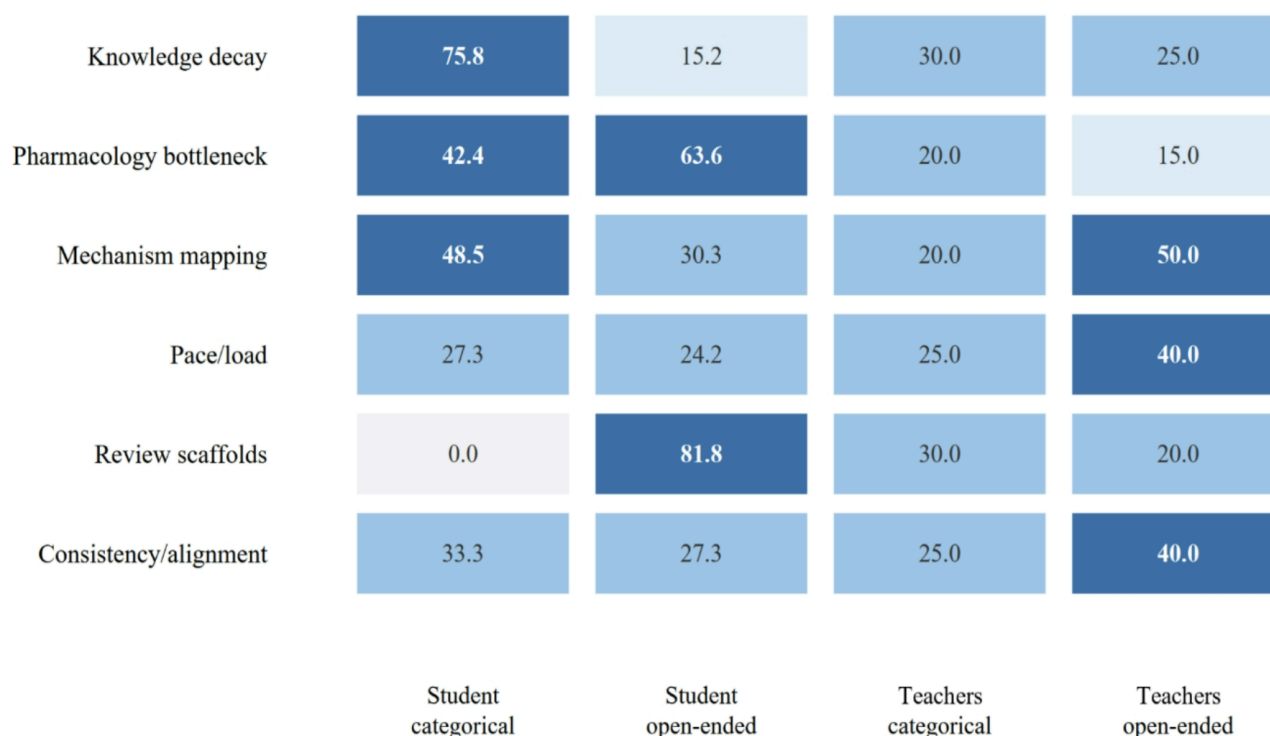


Figure 3

Convergence of learning bottleneck signals across data sources. Rows represent recurrent learning bottlenecks and columns represent student and teacher categorical responses and coded open-text comments. Cell values are respondent percentages or option-selection percentages, depending on the source item. For open-text data, percentages indicate the proportion of respondents whose comments contained the specified signal; multiple codes could be assigned to one response. Darker shading indicates a stronger descriptive signal within that data source and does not represent a formal statistical comparison or an estimate of theme prevalence.

Supplementary Files

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