Introduction and Evaluation of Crossword Puzzle as a Teaching-Learning Tool for Self-Directed Learning in Pharmacology

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Abstract

Background: Self-directed learning (SDL) is a cornerstone of Competency-Based Medical Education (CBME) introduced by the National Medical Commission (NMC) in 2019. Innovative strategies such as crossword puzzles may help improve engagement and retention. This study was aimed to evaluate crossword puzzles as an SDL tool in pharmacology and to explore student and faculty perceptions. **Material and Methods:** A descriptive, prospective mixed-method study was conducted among 150 Phase-II MBBS students. A validated crossword puzzle on ethanol and methanol poisoning was used during SDL sessions. Pre- and post-tests were administered to assess knowledge gain. Student and faculty perceptions were collected via structured Likert scales and open-ended feedback. Data were analyzed using paired t-test, repeated measures ANOVA, and thematic analysis. **Results:** The mean pre-test score (8.6 ± 2.1) improved significantly to 14.9 ± 2.3 in the post-test ($p < 0.001$). Students rated the activity highly on enjoyment (4.70 ± 0.53) and curiosity (4.51 ± 0.59). Retention (4.25 ± 0.69) and motivation (4.40 ± 0.69) were also rated positively, though confidence (4.11 ± 0.76) scored lower. Faculty rated feasibility (4.23 ± 0.68) and regular use (4.27 ± 0.74) highly, but willingness to extend the tool to other SDL sessions was moderate (3.73 ± 0.69). Thematic analysis of student and faculty responses highlighted engagement, improved recall, curiosity, teamwork, and feasibility, along with suggestions for more frequent and competitive use. **Conclusion:** Crossword puzzles significantly improved learning outcomes and were well received by both students and faculty. They represent a practical, engaging, and low-cost strategy to strengthen SDL under CBME and may be extended to other disciplines.
Keywords: Crossword puzzle, Self-directed learning, Pharmacology, CBME, Active learning.

INTRODUCTION

The paradigm shift to Competency-Based Medical Education (CBME) by the National Medical Commission (NMC) in 2019 has fundamentally reoriented undergraduate medical training in India towards the development of competent Indian Medical Graduates (IMGs).[1] A critical pillar of this framework is Self-Directed Learning (SDL), which is posited as essential for cultivating the skills of lifelong learning and adaptive expertise required in modern medical practice.[2] However, the effective implementation of SDL presents a significant pedagogical challenge, particularly in content-dense disciplines.

Pharmacology, a cornerstone of the MBBS curriculum, is emblematic of this challenge. Students frequently grapple with its voluminous content, which encompasses intricate drug nomenclature, complex mechanisms of action, and nuanced therapeutic applications.[3] This often leads to a reliance on superficial rote memorization rather than deep, conceptual understanding, potentially undermining the critical thinking and clinical reasoning skills that CBME aims to foster.[4] Consequently, there is an urgent need to develop and validate innovative instructional strategies that can transform SDL from a passive, solitary activity into an active, engaging, and effective learning process.

Active learning methodologies have consistently demonstrated superiority over passive knowledge transmission in promoting knowledge retention and conceptual mastery.[5] Within this spectrum, educational games and puzzles have emerged as promising tools for enhancing student engagement and motivation.[6] The crossword puzzle, a seemingly simple instrument, requires learners to actively retrieve information, establish conceptual connections, and apply knowledge logically—processes that align robustly with the principles of cognitive constructivism and adult learning theory.[7]

Existing literature provides preliminary evidence supporting the efficacy of crossword puzzles in medical education. Studies conducted in disciplines such as pathology,[8] biochemistry,[9] and physiology,[10] have reported significant improvements in academic performance and learner satisfaction. Within pharmacology specifically, investigations have indicated that crossword puzzles can serve as effective adjunct tools for reinforcing pharmacological concepts and drug knowledge.[11,12] Despite this promising groundwork, several critical knowledge

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gaps persist. Firstly, many existing studies employ a primarily quantitative methodology, focusing on immediate knowledge gains while offering limited granular insight into the qualitative learner and faculty experiences that are crucial for understanding the intervention's holistic impact and implementation mechanics. Secondly, there is a paucity of data evaluating the practical feasibility and perceived utility of integrating such tools into the structured SDL mandates of the CBME curriculum from the faculty's perspective—a key determinant of sustainable adoption. Finally, the application of this tool to complex, high-stakes toxicological topics, such as ethanol and methanol poisoning, which demand integrated understanding rather than mere recall, remains underexplored.

To address these lacunae, this study was designed to conduct a comprehensive mixed-methods evaluation of a validated crossword puzzle as an SDL tool in pharmacology. The primary objectives were:

1. To quantitatively assess the immediate knowledge gain among Phase-II MBBS students on the topic of ethanol and methanol poisoning using a pre-test/post-test model.
2. To qualitatively and quantitatively explore student perceptions across key educational domains, including engagement, motivation, curiosity, and self-reported knowledge retention.
3. To gather detailed faculty feedback on the intervention's feasibility, observed educational impact, and potential for broader integration into the medical curriculum.

By synthesizing quantitative outcomes with rich qualitative data, this study aims to provide a robust evidence base for the strategic use of crossword puzzles as a viable, engaging, and effective pedagogy to enhance the quality and effectiveness of Self-Directed Learning within the CBME framework.

MATERIALS AND METHODS

This study was designed as a descriptive, prospective, mixed-method educational research project and was conducted at a medical college in Himachal Pradesh, over a period of one year. The aim was to evaluate the effectiveness of crossword puzzles as a tool for self-directed learning (SDL) and to capture both student and faculty perceptions of the method.

The study population included 150 Phase-II MBBS students who provided informed consent. All consenting students were included in the study, and no exclusion criteria were applied. In addition, 30 faculty members from the Department of Pharmacology, medical education unit and curriculum committee were invited to provide structured feedback on the intervention.

Prior to the commencement of the study, the protocol was reviewed and approved by the Institutional Ethics Committee. Ethical considerations included obtaining informed consent, ensuring voluntary participation, maintaining confidentiality, and safeguarding anonymity. Participants were informed that they could withdraw from the study at any stage without penalty or the need to provide a reason.

Intervention: Two pharmacology topics were selected for SDL sessions, and crossword puzzles were developed and validated by subject experts. One of the puzzles was specifically designed on the topic of ethanol and methanol poisoning, incorporating 20 across and down questions related to clinical features, toxic metabolites, enzyme systems, drug interactions, and antidot therapy. Sample clues included: "Drug of choice for methanol poisoning," "Specific toxicity of methanol poisoning," "Ethanol is metabolised to acetaldehyde," and "Opioid antagonist used to treat alcohol withdrawal syndrome."

During the SDL session, students were divided into pairs and given 20 minutes to solve the crossword puzzle using open-book resources. The maximum achievable score was 20. Once the activity was completed, answers were discussed collectively, and faculty provided immediate feedback to reinforce key learning points.

To assess knowledge gain, a pre-test was conducted before the crossword activity. The test consisted of a structured set of multiple-choice and short-answer questions (maximum score = 20) covering the same topic. After the crossword activity and feedback discussion, a post-test with an equivalent set of questions was administered to evaluate improvement in knowledge and recall.

Data collection

Data collection was carried out at three levels.

1. **Knowledge outcomes:** Pre-test and post-test scores were collected from all participating students to quantify knowledge gained as a result of the crossword-based SDL session.
2. **Student perceptions:** Students completed a structured questionnaire using a five-point Likert scale to rate their experiences across domains such as enjoyment, curiosity, motivation, retention, and confidence. To complement this quantitative feedback, open-ended questions were included to allow students to describe in their own words how the crossword activity affected their learning and to suggest improvements.
3. **Faculty perceptions:** Thirty faculty members provided structured feedback through a Likert-scale questionnaire covering feasibility, regular use, satisfaction with student learning, student engagement, and willingness to adopt crossword puzzles in other SDL sessions. Faculty were also asked to provide qualitative comments on perceived benefits, limitations, and recommendations for wider application.

This combination of objective test scores, structured perception data, and qualitative feedback ensured a comprehensive evaluation of the crossword puzzle intervention.

Statistical analysis: All quantitative data were entered into SPSS version 27. Descriptive statistics (mean ± SD) were calculated for pre-test, post-test, and feedback scores. The difference between pre-test and post-test scores was analyzed using a paired t-test. Repeated measures ANOVA was applied to compare mean feedback scores across different domains for both students and faculty. Where assumptions of sphericity were violated, Greenhouse–Geisser corrections were applied. Bonferroni-adjusted pairwise comparisons were used to identify significant differences between specific domains. A p value of less than 0.05 was considered statistically significant.

Qualitative data from open-ended student and faculty responses were analyzed thematically. Responses were reviewed independently by two investigators, coded into themes and subthemes, and then discussed to ensure consensus. Illustrative verbatim quotes were retained to enrich the interpretation of quantitative findings.

RESULTS

Student performance: A total of 150 Phase-II MBBS students participated in the study. Analysis of knowledge outcomes revealed a significant improvement in post-test performance compared to the pre-test. The mean pre-test score was 8.6 ± 2.1, while the mean post-test score increased to 14.9 ± 2.3. This difference was statistically significant ($p < 0.001$, paired t-test), indicating a substantial gain in knowledge following the crossword-based SDL session. These results suggest that crossword puzzles were effective in reinforcing pharmacology concepts, particularly in the topic of ethanol and methanol poisoning.

Student perceptions: Student perceptions, measured through a structured Likert-scale questionnaire [Table 1], were overwhelmingly positive. Enjoyable teaching received the highest score (4.70 ± 0.53), followed closely by intellectual curiosity (4.51 ± 0.59) and motivation (4.40 ± 0.69). Retention (4.25 ± 0.69) was also rated positively, although confidence (4.11 ± 0.76) received the lowest rating among domains. Repeated measures ANOVA showed a significant difference across domains ($p < 0.001$). Pairwise comparisons revealed that enjoyment was rated significantly higher than motivation, retention, and confidence, but not significantly different from curiosity.

Thematic analysis of open-ended responses provided rich insights into student experiences [Table 2]. Several recurring themes were identified:

- **Engagement and enjoyment:** Students described the activity as "fun and engaging; not like usual SDL sessions" and "a break from monotony."
- **Improved retention:** Many reported that "solving clues made me revise and retain the topic" and "helped me remember drug names easily."
- **Motivation and curiosity:** Students expressed eagerness to have more such activities, writing "I was excited to solve more puzzles on other topics."
- **Teamwork and collaboration:** Working in pairs was perceived as helpful: "Working in pairs made learning easier and enjoyable."
- **Suggestions for improvement:** Students recommended extending puzzle time ("20 minutes was too short; need more time to complete"), increasing the frequency of sessions, and expanding to other pharmacology topics.

Taken together, these findings highlight that crossword puzzles were not only well received but also enhanced active participation, motivation, and recall.

Faculty perceptions: Feedback from 30 pharmacology faculty members further confirmed the utility of crossword puzzles [Table 3]. The highest ratings were observed for regular use (4.27 ± 0.74) and feasibility (4.23 ± 0.68), followed by positive student attitude (4.23 ± 0.68). Satisfaction with student learning was moderate (4.00 ± 0.74). The lowest score was for willingness to extend the tool to other SDL activities (3.73 ± 0.69), suggesting some hesitation about its broader application. Repeated measures ANOVA indicated significant variation across domains ($p < 0.001$).

Qualitative feedback from faculty (Table 4) highlighted several themes:

- **Feasibility and practicality:** Crossword puzzles were described as "very simple and practical to use in SDL sessions" and "time-efficient, as it did not require extra time beyond the SDL session."
- **Student engagement:** Faculty consistently noted improved attentiveness: "Students were more attentive and involved than usual" and "they seemed excited to learn and solve clues."
- **Educational impact:** Faculty observed better recall, stating "helped students recall difficult drug names" and improved reasoning: "students applied reasoning to solve clues."
- **Suggestions for improvement:** Faculty recommended increasing frequency, introducing competitive elements ("Organizing it as a contest would make it more exciting"), and extending the approach to subjects like physiology and pathology.

The combination of objective test score improvement, positive Likert-scale ratings, and illustrative student and faculty comments provides a clear picture of the educational impact of crossword puzzles. Students not only demonstrated improved knowledge but also reported that the activity was enjoyable, motivating, and memorable. Faculty, while supportive of feasibility and student engagement, suggested adaptations to broaden its use.

Table 1: Student feedback on crossword puzzle teaching (N = 150)		
Domain	Mean ± SD	Pairwise comparison highlights
Enjoyable teaching	4.70 ± 0.53	Significantly higher than Motivation, Confidence, Retention (p<.01); similar to Curiosity
Motivation	4.40 ± 0.69	Higher than Confidence (p<.05), lower than Enjoyable teaching
Confidence	4.11 ± 0.76	Lowest rated, significantly lower than all others (p<.01)
Retention	4.25 ± 0.69	Lower than Enjoyable teaching and Curiosity (p<.05)
Curiosity	4.51 ± 0.59	High rating, comparable to Enjoyable teaching

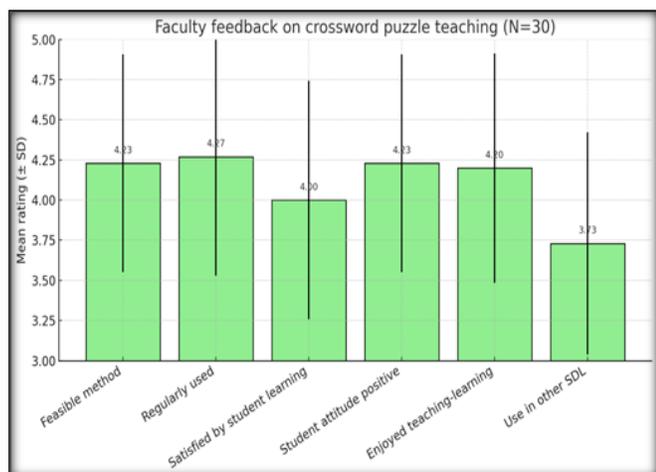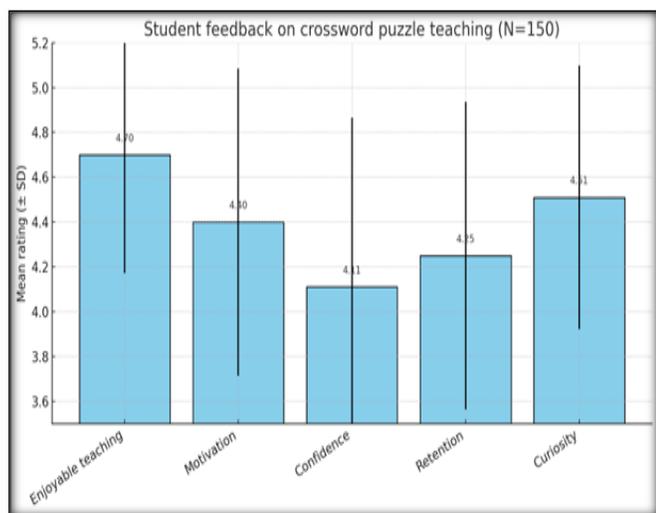| Table 2: Thematic Analysis of Student Feedback		
Theme	Subtheme	Example Student Verbatim
Engagement & Enjoyment	Interactive and fun	"It was fun and engaging; not like usual SDL sessions."
	Break from monotony	"Made the session interesting instead of boring theory."
Improved Retention	Better recall of drug names	"Helped me remember drug names easily."
	Reinforced concepts	"Solving clues made me revise and retain the topic."

Motivation & Curiosity	Stimulated learning interest	"I was excited to solve more puzzles on other topics."
	Competitive spirit	"Wanted to complete faster than others – kept me focused."
Teamwork & Collaboration	Peer learning experience	"Working in pairs made learning easier and enjoyable."
Suggestions for Improvement	More sessions needed	"Should have more such sessions in future."
	Increase time allocation	"20 minutes was too short; need more time to complete."
	Topic variety	"Would like puzzles on all pharmacology topics."

Table 3: Faculty feedback of crossword puzzle

Domain	Mean	Std. Deviation
Feasible method	4.23	0.679
Regularly used	4.27	0.740
Satisfied by student learning	4.00	0.743
Student attitude was positive	4.23	0.679
Enjoyed teaching learning method	4.20	0.714
Would use this tool in other SDL	3.73	0.691

Table: 4 Thematic Analysis of Faculty Feedback

Theme	Subtheme	Example Faculty Verbatim
Feasibility & Practicality	Easy to implement	"Very simple and practical to use in SDL sessions."
	Time-efficient	"Did not require extra time beyond the SDL session."
Student Engagement	Active participation observed	"Students were more attentive and involved than usual."
	Improved attitude toward learning	"They seemed excited to learn and solve clues."
Educational Impact	Reinforced learning	"Helped students recall difficult drug names."
	Encouraged critical thinking	"Students applied reasoning to solve clues."
Suggestions for Improvement	More frequent use	"Should be adopted regularly for SDL topics."
	Include competitive element	"Organizing it as a contest would make it more exciting."
	Expand to other subjects	"Can be used in Physiology or Pathology SDL too."

Student feedback on crossword puzzle teaching (N=150)

Faculty feedback on crossword puzzle teaching (N=30)

Discussion

The present study set out to explore whether crossword puzzles could serve as a useful strategy for self-directed learning in pharmacology. The results suggest that this simple, low-cost tool can make a real difference. Students not only performed significantly better in the post-test compared to the pre-test, but they also described the experience as enjoyable, stimulating, and memorable. This combination of measurable improvement and positive perceptions is important because both knowledge acquisition and learner motivation lie at the heart of effective medical education.

Our finding of improved test scores is in line with earlier reports from India. Gaikwad and Tankhiwale demonstrated that crossword puzzles helped pharmacology students remember drug names and mechanisms more effectively than routine reading.[11] Kolte and colleagues went a step further, showing that puzzles encouraged learners to think critically rather than simply recall facts.[12,13] In the present study too, several students noted that solving the clues forced them to "apply reasoning" and "connect concepts," which echoes Kolte's conclusion that such exercises stimulate higher-order thinking.

Equally striking were the student perceptions. Enjoyable teaching received the highest rating, and feedback such as "fun and engaging; not like usual SDL sessions" or "a break from monotony" appeared repeatedly in their responses. This mirrors Saxena et al, who reported that crossword-based activities in pathology made students more curious and attentive.8 In our setting, curiosity emerged as a strong theme as well—many participants said they were "excited to solve more puzzles on other topics," a sentiment also described by Patrick et al in their pharmacology study.[12]

Retention of knowledge was another consistent benefit. Students frequently wrote that solving clues made them "revise

and retain the topic" or "remember drug names easily." Gaikwad and Tankhiwale similarly emphasised that puzzles are powerful tools for recall.[11] More recently, a physiology study from Dr. D.Y. Patil Vidyapeeth reported that topics taught with crossword puzzles yielded significantly higher test scores than those taught only through lectures.[10] Together, these findings indicate that crossword puzzles are not just entertaining but genuinely helpful in consolidating learning.

Not all outcomes were equally positive. Confidence, while still reasonably high, was rated lowest among the domains. Students often felt that 20 minutes was insufficient to complete the exercise, with comments like "need more time to complete." Patrick et al had also observed that motivation improved with crossword puzzles, but confidence did not always increase proportionally, particularly for complex subjects. This suggests that longer sessions and repeated exposure may help address this gap.[12]

Faculty members also viewed the method positively. They described it as "simple and practical" and noted that it required no extra teaching time. Several remarked that students were "more attentive and involved than usual," observations that resonate with Kolte et al. and Gaikwad and Tankhiwale both of whom highlighted the ease of adoption and the heightened student engagement brought about by crossword puzzles.[11,13] Interestingly, faculty were somewhat cautious about applying this approach to all SDL activities, but their suggestions for introducing competitive elements or expanding into other subjects are encouraging. Saxena et al had earlier advocated for a similar cross-disciplinary use, and our findings indicate that such expansion is worth considering.[8]

The broader literature adds further weight to these results. Thomas and colleagues found that crossword puzzles in biochemistry promoted active participation and critical thinking.9 Vyas et al in Gujarat reported significantly higher scores for students exposed to puzzle-based learning compared to lectures.[14] In pathology, Ponnusamy and Vasanthi showed that puzzles reinforced concepts and improved test outcomes,[15] while in dental education Priyadarshini et al observed that more than 85% of learners strongly agreed puzzles improved recall and problem-solving skills.[16] Even outside pharmacology, these studies underline the versatility of crossword puzzles as a teaching-learning tool.

One strength of the current work lies in its mixed-methods design. Numbers tell only part of the story; the phrases and verbatim comments from both students and faculty provide insight into how and why crossword puzzles worked. Statements such as "wanted to complete faster than others – kept me focused" reveal how puzzles tap into motivation and healthy competition, while faculty remarks like "students applied reasoning to solve clues" highlight their role in encouraging critical thinking.

At the same time, some limitations deserve mention. Being a single-institution study, the findings may not be generalisable to all medical colleges. Only short-term outcomes were assessed; whether crossword puzzles translate into long-term retention remains to be studied.

Finally, the method was not directly compared with other active learning strategies such as case-based discussions or quizzes. Future research, ideally multi-centric and longitudinal, will help clarify where crossword puzzles stand among the array of active learning tools now available.

Despite these caveats, the results have clear implications for Competency-Based Medical Education (CBME), introduced by the National Medical Commission in 2019. CBME places great emphasis on self-directed learning, critical thinking, and the development of lifelong learning habits. Crossword puzzles fit neatly into this framework: they make students take charge of their own learning, they stimulate reasoning rather than rote memorisation, and they transform otherwise dry topics into engaging, interactive sessions. In short, they operationalise the spirit of CBME by making learning both effective and enjoyable.

CONCLUSION

In conclusion, this study reinforces that crossword puzzles are more than just a recreational activity. They are a serious, evidence-based educational tool that improves knowledge retention, encourages critical thinking, and enhances student motivation, while being practical and well accepted by faculty. Incorporating crossword puzzles into pharmacology SDL sessions can therefore be seen as a small but meaningful step towards making CBME a lived reality in the classroom.

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Conflicts of interest

There are no conflicts of interest.

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