

From Discussion to Demonstration: Read–Teach–Validate–Demonstrate an Innovative Peer-Assisted Learning Model for Teaching Pediatric Central Nervous System Examination to Undergraduate Medical Students

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ABSTRACT

Background: Competency-based medical education requires undergraduate learners to participate actively in clinical learning and progressively develop the knowledge, communication, and examination skills needed for safe patient care. Neurological examination in children is particularly challenging because it requires integration of structured examination steps with developmental considerations and interpretation of clinical findings. Traditional demonstration-based sessions may not provide sufficient opportunity for every learner to practice, explain, and receive immediate feedback. The Read–Teach–Validate–Demonstrate (RTVD) model was designed to combine self-directed preparation, peer-assisted teaching, faculty validation, and bedside demonstration within a single structured clinical learning encounter. **Objectives:** The objectives of the study are to evaluate the effect and feasibility of the RTVD teaching model on knowledge acquisition and self-reported confidence among undergraduate medical students learning components of the pediatric central nervous system (CNS) examination. **Materials and Methods:** An educational intervention was conducted during undergraduate pediatrics clinical postings. The source teaching plan divided the CNS examination into component areas and used small-group learning, a brief self-directed reading period, peer teaching, faculty validation, and bedside demonstration. The accompanying Excel dataset contained 30 3rd-year MBBS students distributed equally across three analyzed topic groups – cranial nerve examination, motor system, and reflexes. Knowledge was assessed using 20-item pre- and post-intervention scores, while confidence was recorded on a five-point scale before and after the session. Descriptive statistics and paired comparisons were performed. Mean change, 95% confidence interval (CI), paired *t*-test, Wilcoxon signed-rank test, and within-student effect size were calculated. **Results:** Mean knowledge scores increased from 9.37 ± 1.40 before the intervention to 15.40 ± 1.04 after the intervention, representing a mean absolute gain of 6.03 marks (95% CI 5.39–6.67; $P < 0.001$). The paired-samples *t*-test showed a highly significant improvement ($t = 19.31$, $df = 29$, $P < 0.001$), and the Wilcoxon signed-rank test confirmed the same direction of change ($P < 0.001$). The standardized within-student effect size was large ($d_z = 3.52$). Mean percentage improvement relative to baseline score was 67.9%, while mean normalized gain was approximately 0.56. Confidence increased from 2.40 ± 0.50 to 4.40 ± 0.50 on the five-point scale, a mean increase of 2.00 points ($P < 0.001$). Similar knowledge gains were observed across the three analyzed topic groups, with no significant difference in gain between topics (one-way analysis of variance, $P = 0.958$). **Conclusion:** In this cohort, the RTVD model was associated with substantial improvement in short-term knowledge and self-reported confidence in selected components of pediatric CNS examination. Its educational value appears to arise from the deliberate sequence of preparation, explanation, correction, and clinical demonstration, which increases learner participation while retaining faculty oversight. RTVD is simple, low-cost, and potentially adaptable to other clinical examination skills. Larger controlled studies with objective bedside performance assessment, retention testing, and longer follow-up are required before definitive conclusions about its comparative effectiveness can be made.

Keywords: Active learning, Clinical skills, Central nervous system examination, Competency-based medical education, Pediatric neurology, Peer-assisted learning, Read–teach–validate–demonstrate, Self-directed learning, Undergraduate medical education

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INTRODUCTION

Competency-based medical education (CBME) has shifted the emphasis of undergraduate medical education from passive acquisition of factual information toward demonstrable competence in knowledge, skills, communication, and professional behavior. In clinical disciplines, this requires learners to move repeatedly between conceptual understanding and performance at the bedside. Outcome-oriented curricula therefore benefit from teaching approaches that make students active participants in the learning process rather than recipients of a faculty demonstration alone.^[1,10,20]

The neurological examination is an important component of pediatric clinical assessment but is often perceived by undergraduate learners as difficult to organize and remember. A complete central nervous system (CNS) examination requires a logical sequence involving higher mental functions, cranial nerves, motor and sensory systems, reflexes, coordination, and assessment for meningeal signs. In children, the examiner must additionally adapt the examination to age, developmental stage,

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attention span, and cooperation. The clinical teacher therefore has to achieve two goals simultaneously: Explain the rationale and sequence of the examination and create opportunities for students to perform it themselves.

Traditional clinical teaching frequently relies on a faculty member demonstrating a skill to a group followed by limited individual practice. Although demonstration is valuable, a learner who watches a procedure may not acquire the same competence as a learner who has to explain the steps, identify errors, and perform the skill. Learning in the clinical environment is strengthened when students are actively engaged, receive timely feedback, and connect theoretical knowledge with authentic clinical encounters.^[2,14] Active learning approaches have consistently been associated with improved engagement and learning compared with predominantly passive instructional methods.^[6,11]

Peer-assisted learning (PAL) provides another opportunity to increase participation. In peer teaching, learners explain concepts to classmates, ask and answer questions, identify gaps in understanding, and practice communication in a relatively supportive environment. Medical education literature has described benefits of peer teaching for both the learner and the peer teacher, including improved understanding, confidence, communication, and collaborative learning.^[3,5,12] Small-group learning can also improve participation and provide more opportunities for formative feedback than a large-group session.^[7,18]

Self-directed learning is similarly central to adult learning theory. Knowles described self-directed learning as a process in which learners take initiative in identifying learning needs, selecting resources, and evaluating learning.^[4] In clinical education, however, self-direction should not be interpreted as complete independence from faculty. Learners require supervision, correction, and guidance to prevent misconceptions from becoming established. The Read–Teach–Validate–Demonstrate (RTVD) model was developed around this principle: Students first Read, then Teach their peers, faculty Validate the content, and finally Demonstrate the complete examination at the bedside.

The present study evaluates the RTVD approach using the accompanying student-level dataset. The original teaching document describes 24 undergraduate students and six topic components, whereas the Excel dataset supplied for analysis contains 30 students and three analyzed topic groups. To avoid altering the source data, the present quantitative analysis is based strictly on the 30 records available in the Excel file. The discrepancy should be reconciled against the study log before journal submission.

MATERIALS AND METHODS

Study Design and Setting

This was an educational intervention conducted during undergraduate pediatrics clinical postings. The intervention was designed as a small-group, learner-centered clinical teaching module for pediatric CNS examination. The source document describes the activity as an innovative teaching–learning module integrating self-directed learning, peer teaching, faculty validation, and bedside demonstration.

Participants

The Excel dataset included 30 3rd-year MBBS students. Sixteen participants were female (53.3%) and 14 were male (46.7%). Age

ranged from 23 to 26 years, with a mean age of 24.37 ± 0.93 years. The dataset contained three groups of 10 students each. The analyzed topic assignments were cranial nerve examination, motor system examination, and reflexes.

RTVD Intervention

The teaching sequence consisted of four linked stages. In the Read stage, learners undertook a brief period of self-directed preparation using standard learning resources. In the Teach stage, each small group explained its assigned component to peers. This required students to organize information, articulate examination steps, and respond to questions. In the Validate stage, faculty reviewed the teaching, corrected inaccuracies, emphasized clinically important points, and clarified doubts. Finally, in the Demonstrate stage, the faculty demonstrated the complete CNS examination on a pediatric patient, explicitly linking theoretical steps to bedside findings. The original teaching plan describes six CNS components – higher mental functions, cranial nerves, motor system, sensory system, reflexes, and cerebellar/meningeal assessment – although only three components were represented in the quantitative Excel dataset.

Outcome Measures

The primary quantitative learning outcome was change in a 20-item knowledge score from pre-test to post-test. Secondary outcomes included absolute score gain, percentage improvement recorded in the dataset, and self-rated confidence on a five-point scale before and after the intervention. The original manuscript also describes verbal feedback and formative observation, but the supplied Excel workbook contained no completed records for the Faculty Observation or Qualitative Feedback sheets; therefore, these outcomes were not included in the quantitative analysis.

Statistical Analysis

Continuous variables were summarized as mean $\pm$ standard deviation (SD). Pre- and post-intervention knowledge scores and confidence ratings were compared using paired-samples *t*-tests. Because the knowledge scores were bounded and paired, the Wilcoxon signed-rank test was also used as a non-parametric sensitivity analysis. The mean absolute gain was accompanied by a 95% confidence interval. Within-student standardized effect size was calculated as the mean paired difference divided by the SD of the paired differences. Differences in gain across the three topic groups were explored using one-way analysis of variance (ANOVA). Statistical significance was considered at $P < 0.05$.

RESULTS AND OBSERVATION

Participant Characteristics

Characteristic	Result
Sample size	30
Age, years; mean $\pm$ SD	24.37 $\pm$ 0.93
Age range	23–26
Female (%)	16 (53.3)
Male (%)	14 (46.7)
MBBS year (%)	3 rd year I; 30 (100)
Analyzed topic groups	3
Students per topic group	10 each

SD: Standard deviation

All 30 records contained complete pre-test, post-test, and confidence values. No student identifiers were present in the workbook, which preserved anonymity but prevented independent verification of record linkage beyond the row-level paired structure.

Knowledge Outcomes

Measure	Pre-intervention	Post-intervention	Change	P-value
Knowledge score (/20), mean±SD	9.37±1.40	15.40±1.04	+6.03	<0.001
95% CI for mean score			5.39–6.67	
Percentage improvement, mean	—	—	67.9%	
Normalized gain, mean	—	—	0.56	

SD: Standard deviation, CI: Confidence intervals

Mean knowledge increased by 6.03 marks on the 20-point test. The paired *t*-test demonstrated a highly significant improvement ($t = 19.31$, $df = 29$, $P < 0.001$). The Wilcoxon signed-rank test also showed a significant improvement ($P < 0.001$). The within-student standardized effect size was 3.52, indicating a very large magnitude of short-term change in this dataset. The mean percentage improvement calculated from the supplied percentage-improvement variable was 67.9%. The mean normalized gain, calculated as the observed gain divided by the maximum possible gain remaining after the pre-test, was approximately 0.56. Individual pre- and post-test scores are shown in Figure 1, and the distribution of individual gains in Figure 2; every student showed an increase in score.

Confidence Outcomes

Measure	Before	After	Mean change	P-value
Confidence (1–5), mean±SD	2.40±0.50	4.40±0.50	+2.00	<0.001

SD: Standard deviation

Self-rated confidence increased by an average of 2.00 points on the five-point scale (Table 3, Figure 3 shows the individual change in self-rated confidence before and after the RTVD session). The paired comparison was statistically significant ($t = 12.04$, $df = 29$, $P < 0.001$). The consistency of the confidence ratings is notable: The pre-intervention scores ranged from 2 to 3, whereas post-intervention scores ranged from 4 to 5.

Topic-Wise Outcomes

Topic	n	Pre mean	Post mean	Gain	Confidence before	Confidence after
Cranial nerve	10	9.30	15.40	6.10	2.40	4.40
Motor system	10	9.50	15.40	5.90	2.40	4.40
Reflexes	10	9.30	15.40	6.10	2.40	4.40

Topic-wise results are shown in Table 4 and Figure 4 showing the distribution of individual knowledge-score gains. Knowledge gains were closely comparable across the three analyzed groups:

6.10 marks for cranial nerve examination, 5.90 marks for motor system examination, and 6.10 marks for reflexes. One-way ANOVA showed no evidence of a difference in gain between the three topics ($P = 0.958$). These findings suggest that the learning effect was not confined to one particular examination component, although the small group size limits interpretation.

DISCUSSION

The principal finding of this educational intervention was a substantial improvement in short-term knowledge after implementation of the RTVD model. The mean score increased from 9.37 to 15.40 out of 20, with an average gain of 6.03 marks and a very large within-student effect size. Confidence also increased by two points on a five-point scale. Because the study used a single-group pre–post design, the results should be interpreted as evidence of an association between participation in RTVD and improved immediate learning rather than proof that RTVD is superior to conventional teaching.

The strength of the RTVD model lies in its sequence. The Read phase provides learners with a defined preparation task, preventing the peer-teaching activity from becoming an unstructured discussion. Self-directed preparation is consistent with adult learning principles, in which learners take an active role in identifying and addressing their learning needs.^[4] In the present model, however, self-directed learning is immediately followed by peer explanation and faculty validation. This combination is important because independent preparation without feedback may allow misconceptions to persist.

The Teach phase changes the learner from a recipient of information into an explainer. Explaining a clinical examination requires selection of relevant information, organization of steps, and verbalization of reasoning. Peer teaching therefore creates a form of retrieval and elaboration practice. Previous work has supported peer teaching as a useful strategy in medical education, with benefits for knowledge, confidence, and communication.^[3,5,12] A systematic review by Burgess *et al.* also highlighted the growing role of peer tutoring in medical education and its potential to benefit both peer tutors and learners.^[12] The improvement observed in the present study is compatible with this broader educational literature.

The Validate phase is arguably the key safeguard of the model. Peer teaching is not intended to replace faculty expertise. Instead, faculty members act as expert validators who identify errors, correct technique, and emphasize clinically meaningful points. This is particularly important in pediatric neurological examination, where apparently small differences in technique or interpretation can affect clinical conclusions. Effective clinical teaching depends on supervision, feedback, and opportunities to connect observed findings with underlying concepts.^[2,14] The RTVD structure preserves these elements while giving students more responsibility during the learning encounter.

The final Demonstrate phase reconnects discussion with authentic clinical practice. Experiential learning emphasizes the transformation of theoretical knowledge through experience and reflection.^[15] A bedside demonstration allows learners to observe how an experienced clinician adapts the examination to a real child, integrates cooperation and developmental considerations, and interprets findings in context. This is particularly relevant to CBME because competence cannot be inferred solely from written knowledge. Assessment and teaching should ultimately support performance in realistic clinical settings.^[13]

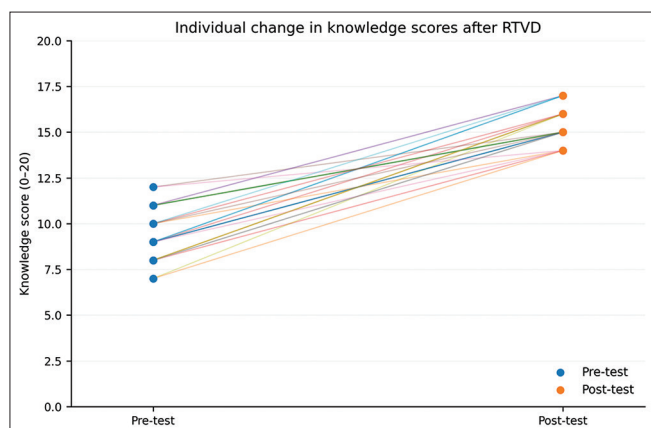


Figure 1: Individual pre-test and post-test knowledge scores. Each line represents one student ($n=30$), demonstrating the paired nature of the analysis

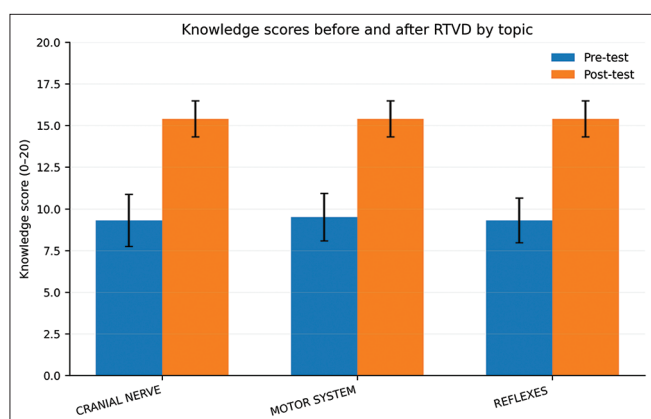


Figure 2: Topic-wise knowledge scores before and after Read-Teach-Validate-Demonstrate. Bars represent mean scores and error bars represent standard deviation

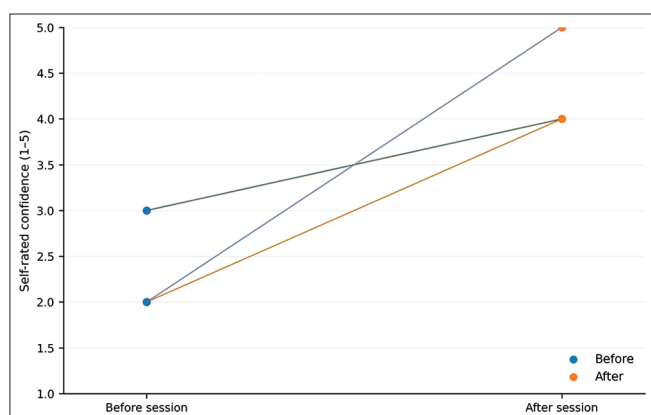


Figure 3: Individual change in self-rated confidence before and after the Read-Teach-Validate-Demonstrate session. Each line represents one student ($n=30$)

The magnitude of improvement in the present dataset is encouraging. The mean percentage improvement relative to baseline was approximately 67.9%, and the normalized gain was about 0.56. All students demonstrated an increase in their recorded knowledge score, and the statistical evidence remained strong using both

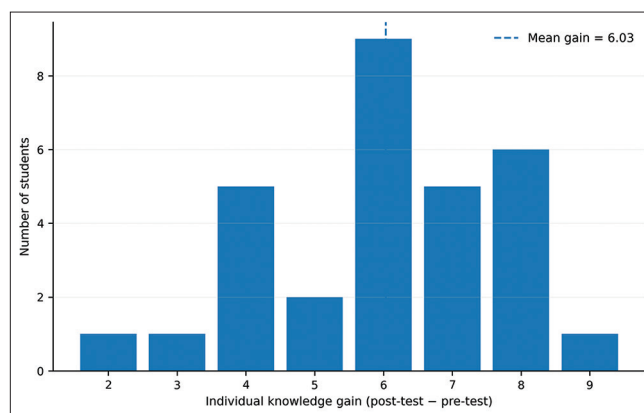


Figure 4: Distribution of individual knowledge-score gains. The dashed line indicates the mean gain of 6.03 marks

parametric and non-parametric paired analyses. Such consistency suggests that the intervention was associated with a broad rather than isolated improvement within this cohort. However, the large effect size should not be interpreted without considering the study design. In a small single-group pre-post study, testing effects, short-term recall, regression to the mean, and the immediate influence of the teaching session can all contribute to observed improvement.

The confidence findings provide a useful complementary perspective. Confidence increased from 2.40 to 4.40, suggesting that learners felt considerably more prepared after the activity. This may reflect increased familiarity with the examination sequence, opportunities to verbalize steps, and reassurance from faculty validation. Nevertheless, self-reported confidence should not be equated with competence. A learner may feel confident without demonstrating accurate technique, and confidence may increase immediately after a successful teaching session without corresponding long-term retention. Future studies should therefore combine confidence scales with objective structured clinical examination (OSCE) scores, direct observation, checklists, or workplace-based assessment.

An important finding was the similarity of gains across cranial nerve examination, motor system examination, and reflexes. There was no significant difference in mean gain among the three topic groups. This supports the possibility that RTVD is a general teaching architecture rather than a topic-specific intervention. Its transferable elements – preparation, explanation, validation, and demonstration – could be applied to respiratory examination, cardiovascular examination, abdominal examination, developmental assessment, procedural skills, and other bedside competencies. Small-group teaching is particularly valuable where faculty time is limited, because learners can contribute to one another's learning while faculty concentrate on correction and higher-order guidance.^[7]

The model also aligns with the broader movement toward active learning. Evidence from educational research indicates that active participation can improve learning compared with passive instructional approaches.^[6,11] Problem-based and collaborative approaches similarly emphasize learner engagement, application of knowledge, and structured facilitation.^[8,9,19] RTVD is less resource-intensive than a fully problem-based curriculum and does not require sophisticated technology. This may make it practical in busy clinical departments where teaching time, faculty availability, and patient access are constrained. Small-group learning can also improve participation and provide more opportunities for formative feedback than a large-group session.^[7,18]

From a faculty-development perspective, RTVD may also redefine the teacher's role. Instead of delivering every component of the session, the teacher designs the learning sequence, observes learners, validates content, and demonstrates expert performance. This is consistent with the concept of teaching as a professional competency that includes facilitation, feedback, and assessment rather than information transmission alone.^[16] Learner motivation is also likely to be supported when students perceive autonomy, relevance, and opportunities for meaningful participation.^[17]

The present study has several limitations. First, the sample was small and drawn from a single institution and a single MBBS cohort, limiting generalizability. Second, the study lacked a control or comparison group receiving conventional teaching. Consequently, the observed improvement cannot be attributed exclusively to RTVD. Third, the outcomes were measured immediately after the intervention; long-term retention was not assessed. Fourth, the supplied workbook did not contain completed faculty-observation or qualitative-feedback records, so claims about communication, teamwork, bedside performance, and learner satisfaction could not be statistically verified from the available dataset. Fifth, the knowledge test characteristics, item difficulty, validity, and reliability were not documented in the supplied materials. Finally, the source manuscript reports 24 students and six CNS components, whereas the Excel dataset contains 30 students and three analyzed components. This discrepancy should be resolved before submission, and the final manuscript should use one verified sample description.

Despite these limitations, the study provides a useful preliminary evaluation of a practical teaching strategy. The intervention is simple enough to be incorporated into routine clinical postings without substantial additional resources. Its most important educational contribution may be structural rather than technological: It creates a deliberate progression from preparation to explanation, from explanation to correction, and from correction to authentic clinical demonstration. This progression can help transform a short clinical teaching encounter into an active learning experience.

Future research should use a controlled or randomized design comparing RTVD with conventional demonstration-based teaching. Larger samples across multiple institutions would improve external validity. Outcomes should include immediate knowledge, delayed retention, objective clinical skill performance, communication, learner engagement, and faculty-rated competence. A validated checklist or OSCE station could determine whether increased knowledge and confidence translate into accurate examination performance. Qualitative interviews or thematic analysis of student and faculty experiences would also clarify which RTVD component contributes most to learning. Repeated exposure across several clinical topics could determine whether the model produces cumulative benefits.

CONCLUSION

The RTVD model – Read, Teach, Validate, and Demonstrate – was associated with marked improvement in immediate knowledge and self-reported confidence among the 30 undergraduate students represented in the supplied dataset. The mean knowledge score increased by 6.03/20 marks, and confidence increased by 2.0/5 points, with highly significant paired comparisons. Comparable gains across the analyzed topic groups suggest that the model may be adaptable across different components of clinical examination. RTVD combines the strengths of self-directed learning, PAL, faculty supervision, and bedside demonstration while remaining simple and resource-efficient. It should be regarded as a promising educational

innovation requiring confirmation through controlled studies and objective assessment of clinical performance and retention.

Key Educational Implications

- RTVD provides a structured sequence for converting learners from passive observers into active participants
- Peer teaching creates opportunities for retrieval, explanation, communication, and collaborative learning
- Faculty validation preserves accuracy and prevents peer-generated misconceptions from becoming established
- Bedside demonstration links theoretical discussion to authentic clinical performance
- The model is feasible for small-group clinical teaching and can be adapted to other examination skills
- Future evaluation should prioritize objective clinical performance and delayed retention rather than relying only on immediate post-test and confidence measures.

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