



Assessing How Students Learn in Team-Based Learning: Validation of the Knowledge Re-Consolidation Inventory[☆]

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Abstract

Purpose: The purpose of the present study was to establish the construct validity of a new instrument to measure psychological learning processes associated with Team-based learning (TBL), the Knowledge Re-Consolidation Inventory (KRCI). The instrument was designed to measure six factors: (1) self-guided preparation, (2) knowledge consolidation, (3) retrieval practice, (4) peer elaboration, (5) feedback, and (6) transfer of knowledge.

Method: Two samples were taken, consisting in total of 197 first- and second-year medical students from Singapore. To establish the construct validity of the KRCI, two confirmatory factor analyses were conducted (CFA). First, an exploration sample ($N=90$) was taken from the second-year medical students to conduct a preliminary CFA, and it resulted in elimination of items with poor psychometric properties. A confirmatory sample ($N=107$) was then taken from the first-year medical students to conduct a second CFA to cross-validate the KRCI with reduced items.

Results: From the original 38 items, 16 remained. The resulting model fitted the data well. The second CFA with the cross-validation sample replicated the findings of the first analysis and supported the factorial structure of the hypothesised six-factor model. Tests of factorial invariance demonstrate that the factorial structure of the KRCI was stable across measurements.

Discussion: The results of the study suggest that the KRCI is a valid and reliable instrument capable of measuring the six psychological mechanisms underlying TBL.

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Keywords: Construct validity; Confirmatory factor analysis; Team based learning; Knowledge Re-Consolidation Inventory

1. Introduction

Since the early 2000s, an increasing number of educational institutions worldwide have adopted Team-based learning (TBL) as their instructional strategy,^{1–3}

including a growing number of medical and nursing schools.⁴ TBL typically consists of three distinct phases.⁵ The first phase is the preparation phase and it occurs before the actual TBL session. During this phase, students study the assigned learning resources to prepare themselves for the topic to be discussed during the TBL session. The second and third phases are conducted during the TBL session itself when students come together and work in small teams (5 to 7 students). The second phase is referred as the readiness assurance

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phase which allows students to test their knowledge and understanding; first individually by means of an iRAT (individual readiness assurance test, where students attempt the multiple-choice questions individually) and then within the team by means of the tRAT (team readiness assurance test, which is the same as the iRAT but it is discussed within the team). During the tRAT, teams receive immediate computer-based feedback on the correctness of the answers chosen, and the teams engage in a class discussion to clarify the most difficult questions and seek clarification from the teacher. The teacher also provides elaborative feedback to the students. The third phase is the application phase. During this phase, students are presented with case studies or vignettes that deal with real-world problems faced by professionals in the field. Students in their teams have to apply what they have learnt during the first two phases. Answers are then discussed in class and the teacher provides additional explanations and/or a summary of what was learnt.

Studies suggest that this instructional approach is capable of expanding students' conceptual and procedural knowledge,^{6–8} which contributes to better performance,^{2,4,9,10} better critical thinking and problem-solving skills,^{6–8,11,12} and at the same time, improves their interpersonal skills such as communication, teamwork, and leadership skills.^{8,12,13} Despite the growing popularity of TBL and the emerging evidence that it is an effective instructional approach, little is known about its inner workings. What are the psychological mechanisms that govern TBL and which particular mechanism is conducive for learning? These are questions that have not been empirically addressed.

Schmidt and colleagues¹⁴ have recently proposed a theoretical framework describing the underlying psychological mechanisms of TBL. They suggest that there are six distinct psychological mechanisms, which coincide with the distinctive phases and features of TBL. These mechanisms are: (1) *Guided self-preparation*, which corresponds to the preparation for a TBL session (similar to the flipped classroom concept¹⁵). Preparation occurs prior to classroom time, where students are provided with pre-reading materials for initial self-directed acquisition of knowledge. The second mechanism is (2) *Memory consolidation*. Memory consolidation occurs after knowledge encoding, mainly during sleep, whereby the newly acquired memory is stabilised, enhanced, and integrated with pre-existing long-term knowledge networks.^{16–18} In TBL, students typically have at least 24 hours between preparation and the TBL session and it is assumed that a good night's sleep will allow for memory consolidation at the synaptic level. The third

mechanism is (3) *Retrieval practice*, which corresponds to the iRAT. Retrieval practice is the act of retrieving information from long-term memory,¹⁹ which occurs when students attempt the iRAT during TBL as they have to retrieve what they have learnt previously when they prepared for the session. Research has shown that having an opportunity to retrieve knowledge from memory enhances learning because it enhances the extent to which knowledge is embedded (and re-embedded) in memory.^{19–21} The fourth mechanism is (4) *Peer elaboration*, which corresponds to the tRAT. Peer elaboration refers to “collaborative and co-operative” learning in which students' engage in mutual teaching and learning within peer groups,^{22,23} discernibly improving learning and understanding.²⁴ This occurs during tRAT when students in TBL discuss the answer options to the iRAT. The fifth is (5) *Feedback*, which corresponds to burning questions after tRAT (also referred to as “written team appeal”). Receiving feedback that is specific and timely has been shown to have a positive effect on learning because it helps to clarify misconceptions and stimulate deeper processing of information.²⁵ It also encompasses positive reinforcement.²⁶ The sixth mechanism is (6) *Transfer of knowledge*, which corresponds to the application exercises. Transfer is broadly referred to as applying one's knowledge to new, unfamiliar contexts.^{27,28} This is encouraged during TBL when students engage with the application exercises. During these exercises, students have to apply what they have learnt to new contexts and situations to solve novel problems.

Although Schmidt et al.¹⁴ provide a first account of the psychological basis for TBL, it should be noted that their proposal is theoretical in nature; currently there is only limited empirical evidence available for the knowledge re-consolidation theory that stems directly from TBL research. What is needed at this point is an instrument that is capable of adequately measuring these six psychological mechanisms. This would not only enable testing the knowledge re-consolidation theory, but also provide deeper insights into the inner workings of TBL.

Reviewing the TBL literature in search of suitable instruments, it becomes apparent that there are not many instruments available. We were only able to find two validated instruments in the Web of Science database. Vasan and his colleagues²⁹ developed a 15-item questionnaire to measure medical undergraduate students' perceptions of TBL and teamwork. Eight of the items assess perceptions of TBL, (e.g., TBL helped me prepare for course examinations) and the other seven items assess perceptions of teamwork (e.g., I

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