Team-based learning: Putting learning sciences research to work in the economics classroom

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In this paper we describe how Team-Based Learning (TBL) intentionally promotes learning strategies that have been identified by learning sciences research as highly effective to create powerful learning environments for students. The paper illustrates how learning sciences principles and research findings inform and support the TBL framework, focusing on six evidence-based learning science strategies: (1) effortful retrieval practice, (2) spaced/distributed retrieval practice, (3) self-elaboration, (4) use of activities employing concrete examples, (5) appropriate sequencing of direct instruction and student exploration, and (6) repeated use of highly structured group-based activities throughout a course. The systematic and intentional integration of these strategies in TBL classes creates the potential for powerful learning relative to courses that fail to intentionally take into account learning sciences research in their design and pedagogy.

Keywords: team-based learning, evidence-based teaching, learning sciences, evidence-based learning strategies

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INTRODUCTION

Over the past two decades, learning sciences research has provided important insights about how students learn as a foundation for effective teaching, beginning with the National Research Council's seminal report, *How People Learn* (National Research Council, 2000). During this time, an extensive literature has developed in support of the use of learning sciences findings to inform course design and instruction (see, for example, Brown, Roediger, and McDaniel 2014; Schwartz, Tsang, and Blair 2016; Weinstein, Sumeracki, and Caviglioli 2019; and Agarwal and Bain 2019). Yet, most instructors fail to explicitly incorporate research findings on how students learn in their pedagogical practice (Howard-Jones 2014; Roediger and Pyc 2012).[1]

Research findings from the learning sciences suggest a variety of teaching strategies to increase student learning, including the following:

(1) Providing students with repeated opportunities for **effortful retrieval practice** with feedback
(2) **Distributing and spacing** student retrieval practice across time
(3) Incorporating practices that regularly promote the development of **self-elaboration** skills
(4) Using activities that employ **concrete examples** requiring students to apply course concepts in multiple ways
(5) Blending **appropriate sequencing** of direct instruction and student exploration
(6) Integrating **highly-structured group-based activities** throughout a course

In this paper we describe how Team-Based Learning (TBL) intentionally promotes these six strategies to create a powerful learning environment for students. While many economics instructors may already incorporate one or more of these strategies in their courses, TBL has the potential to enhance student learning in economics courses by combining all of these strategies in a unified manner. Below, we focus on how learning sciences principles and research findings inform and support the TBL framework, which incorporates the systematic use of highly-structured team-based activities to promote pre-class preparation and in-class engagement of students.[2]

HOW TBL PROMOTES EVIDENCE-BASED TEACHING AND LEARNING STRATEGIES

As noted in *How People Learn*, "to develop competence in an area of inquiry, students must have opportunities to learn with understanding" (16). Learning with understanding goes beyond rote learning of facts and models and involves expertise, the ability for learners to "use what they have learned to solve novel problems" (9). In economics, McGoldrick and Garnett (2013) and Colander and McGoldrick (2009) have advocated for this type of learning with understanding using a "big think" approach that challenges students to address context-rich questions that do not provide neat, simple solutions. TBL shares similar educational goals and provides a coherent learning framework for exploring these types of questions.[3] Learning scientists, in particular cognitive psychologists, have shown that the six teaching strategies listed above promote learning with understanding. In the sections below, we illustrate how TBL systematically incorporates these strategies throughout a course, highlighting for instructors the potential student learning benefits of adopting TBL pedagogy.

Strategy 1: Providing Repeated Opportunities for Effortful Retrieval Practice with Feedback

Weinstein, Sumeracki, and Caviglioli (2019, 83-85) note that two research-based strategies for effective learning dominate learning science research: effortful retrieval practice and spacing/distributed practice. In this section we focus on the role of retrieval practice in TBL; the next section examines the role of spacing and distributed practice.

Retrieval practice is grounded in the effortful recall of information, which reinforces brain pathways. As Brown, Roediger and McDaniel (2014, 28) explain, "To be effective, retrieval must be repeated again and again, in spaced out sessions so the recall, rather than becoming a mindless recitation, requires some cognitive effort."[4] Research on the need to reinforce brain pathways through retrieval to produce meaningful and durable learning is well established in cognitive science; Roediger and Karpicke (2006); Roediger, Putnam, and Smith (2011); and Roediger and Karpicke (2018) provide useful research reviews, while Agarwal, et al. (2013) provide a useful "how to" guide on incorporating retrieval practice in the classroom or online. Schell and Butler (2018, 5-6) provide a useful summary of evidence-based benefits of retrieval practice on learning, including direct impacts on memory, long-term retention, and transfer of learning, as well as indirect benefits, including feedback to students and instructors on the level of student understanding.

Schwartz, Tsang, and Blair (2016, 64-75) explain that feedback further boosts the learning that happens during retrieval practice. Timely, specific, understandable feedback allows learners to confirm areas of knowledge that are correct and to identify where further learning needs to occur. These authors note that feedback is particularly effective at promoting student learning when there is opportunity and motivation to revise work on the basis of that feedback.

TBL class structure requires repeated effortful retrieval practice by students throughout the semester and systematically provides timely, specific, and informative feedback to students on their learning during team-based activities. A TBL course typically is divided into 5-7 topical modules in a fifteen-week semester. Each module begins with a Readiness Assurance Process, consisting of out-of-class preparation by students (typically, reading a textbook chapter, watching videos, or listening to podcasts), an individual multiple-choice quiz (iRAT), and an in-class identical (or very similar) team-based quiz (tRAT). The majority of time in each module is made up of a series of Application Exercises (AEs) that challenge students to apply and synthesize economic concepts and principles through the analysis of an increasingly complex set of real-world examples.

The Readiness Assurance Process initiating each module provides students with multiple opportunities for retrieval practice, beginning with the iRAT, which is similar to a traditional reading quiz. This kind of practice testing, which requires effortful recall, has been shown to be a useful and effective tool for retrieval practice, "making the tested knowledge easier to call up again in the future" (Brown, Roediger, and McDaniel 2014, 28). Dunlosky et al. (2013) rate practice testing as a high impact, research-supported activity.

In addition to providing additional retrieval practice, tRATs provide timely and informative feedback that strengthens long-lasting learning. When completing tRATs, students discuss and debate the same (or very similar) questions as a team that they completed individually on the iRAT. During this time, students express their own understanding of a question, listen to team members' explanations, receive feedback from their peers about their understanding, and modify their own thinking before making team selections using a scratch-off "IF-AT" form.[5] As Ruder, Maier, and Simkins (2021, page number to be determined) explain, when using the IF-AT form "students scratch off the material covering the space for their chosen answer, similar to scratching off spaces on a lottery ticket. If the attempt is correct, there will be a star in the space." The results of their choices are immediately revealed, providing instantaneous feedback on whether the team's reasoning for a question was correct. If an answer is not correct on a scratch-off attempt (the star is not revealed) students have the chance to revise their understanding and make additional attempts to arrive at the correct answer (reveal the star), with successive attempts earning fewer points. The tRAT process meets the criteria for "timely, specific, and understandable" feedback laid out by Schwartz, Tsang, and Blair (2016).

AEs, which follow the Readiness Assurance Process in each TBL module in a course, provide additional effortful retrieval practice and immediate feedback that create more opportunities to enhance learning. AEs require students to recall information from pre-class preparation activities, bring to bear knowledge from previous modules, interact with teammates to determine a consensus response (from a limited number of choices), and prepare to present the team's reasoning in a class-wide discussion among team reporters. Each step promotes effortful recall, a key to effective retrieval practice. Further, AEs provide students with timely and specific feedback when teams report out and defend their reasoning for specific team choices and again when the instructor wraps up each exercise with an expert's perspective on the economic issues considered in the AE.

Strategy 2: Promoting Spaced/Distributed Retrieval Practice

A second highly-researched teaching/learning strategy is the use of spaced practice. Spaced (or *distributed*) practice is closely related to retrieval practice and focuses on *when* retrieval practice is done. Spacing studying and practice in smaller increments over time, rather than in fewer, longer, "massed practice" sessions (often referred to as "cramming") has been shown to improve long-term learning of students in a wide variety of tasks. Carpenter, et al. (2012) and Fiske and Kang (2016) provide useful reviews of the student learning impact of spaced practice. Like retrieval practice, Dunlosky et al. (2013) also rate spaced/distributed practice as a high impact, research-supported activity for promoting long-term learning.

TBL inherently promotes spaced retrieval practice by motivating student engagement with the material early in a module and then spreading out the need to retrieve key course concepts and apply them repeatedly within a module, rather than simply just prior to taking an exam. Most of the time in a TBL course is spent actively practicing course concepts via AEs, which require students to retrieve ideas and concepts first introduced in the Readiness Assurance Process and then apply them in new ways multiple times over, say, a two-week period. As a result, retrieval practice is naturally distributed within each module and then across modules throughout the course. Repeated opportunities for effortful retrieval practice, intentionally and systematically spaced by design over time in TBL-based courses, provide a strong foundation for the teaching practices highlighted in the following sections. Like spaced retrieval practice, learning science research has shown that these practices promote and reinforce meaningful student learning.

Strategy 3: Promoting the Development of Self-elaboration Skills

Self-elaboration is an effective learning strategy that supports spaced retrieval practice and is key to developing *understanding* (Weinstein, Sumeracki, and Caviglioli 2019, 101-107). Learning with understanding is characterized by the ability to connect new information to pre-existing knowledge in meaningful ways, see beyond the surface features of concepts, ideas, and information (e.g. simply focusing on re-creating graphs used in economics, listing reasons for shifts in curves, and memorizing definitions of economic concepts), and understand how and when particular concepts, models, or ideas can be used to address new or novel problems.

Weinstein, Sumeracki, and Caviglioli (2019) explain that "elaborative interrogation," a particular type of elaboration practice that involves students asking and answering "how" and "why" questions, is particularly effective at enhancing understanding. They also highlight the importance of this process for long-lasting learning, noting that "as you are elaborating, you are making connections between old and new knowledge, making the memories easier to retrieve later" (105).

The authors further point out that the intentional practice of "self-explanation" has similar learning benefits, especially when learning a complex set of new knowledge, as shown in Chi et al. (1994). Roediger and Pyc (2012) highlight the use of elaborative interrogation and self-explanation as among the most effective educational techniques to improve student learning and comprehension, based on both laboratory and classroom-based research, noting that both elaborative interrogation and self-explanation encourage students to connect new information to prior knowledge, a necessary condition for understanding.

The structure of TBL classes requires students to engage in elaborative interrogation and self-explanation on to-be-learned material regularly. During tRATs, for example, students consider each question as a team, explaining to each other why one answer is correct and another incorrect, coming to consensus on a choice, then repeating the process if the earlier choice is incorrect.

AEs, which constitute the largest component of TBL courses, are a structured form of elaborative interrogation and self-explanation – both within the team discussions and during the debriefing session. AEs require students to make specific choices posed by the exercises and support those choices with careful economic reasoning. This task requires extensive elaboration on "how" and "why" their team chose a specific answer for each exercise, which typically focuses on a concrete, real-world example of an economic event, data interpretation, or a policy issue.

TBL provides strong incentives for *each* student in a team to participate in self-elaboration during the AE process. As described in Ruder, Maier, and Simkins (2021) team members are highly accountable to one another for participating at a high level in AE activities, in particular because all members of the team need to be ready to present the team's choice during the AE reporting session, along with the economic reasoning and analysis underlying that choice. Slavin (2014) notes that choosing team reporters randomly after the teams' choices are made (and having all team members' grades depend on the reporter's effort) is sufficient to promote each student's participation in the team's elaborative interrogation and self-explanation processes.

Strategy 4: Using Concrete Examples that Require Students to Apply Course Concepts

Closely related to elaborative interrogation and self-explanation is the strategy of using concrete examples to provide context for theoretical ideas, concepts, and models. Using concrete examples helps students learn abstract ideas and effectively apply them, especially when instructors make explicit the connections between the concrete example and abstract concept. Failure to include this step can lead to students simply remembering the general characteristics of the example rather than the underlying concepts – a significant issue for novice learners.

According to Weinstein, Madan, and Sumeracki (2018) concrete examples improve learning by concisely conveying information and making that information easier to remember. Lab research indicates that concrete examples provided along with abstract concepts improve student retention of the latter (see Caplan and Madan 2016; Madan, Glaholt, and Caplan 2010; Paivio 1971). Gick and Holyoak (1983) show that using a variety of examples illustrating similar concepts applied in different contexts improves students' ability to transfer learning to new contexts in the future.

Real-world examples are a subset of the more general "concrete example" category. Rawson, Thomas, and Jacoby (2015, 483) examine the strategy of "presenting students with concrete examples that illustrate how the abstract concepts can be instantiated in real-world situations" and find that use of these types of examples (what they call "illustrative examples") "enhanced conceptual learning relative to only providing concept definitions" (499), especially when the concept definitions were presented along with the examples. Their findings are consistent with theoretical frameworks on transfer of learning that suggest a positive relationship between the use of these types of concrete examples in teaching and students' ability to later apply the underlying concepts in real-world contexts.

In economics, Schneider (2012, 285) argues that the principles of economics course should include "a set of relevant applications … drawn from the world around us" rather than simply presenting economic concepts as a set of abstract models, a common practice in introductory courses. The "big think" approach discussed earlier, advocated by McGoldrick and Garnett (2013) and Colander and McGoldrick (2009), also highlights the importance of using context-rich, real world problems to promote learning with understanding in economics courses. As *How People Learn* (p. 139) notes, using relevant real-world examples can help students "make sense of what they are learning." Such sense-making promotes increased understanding, and ultimately expertise, which allows students to more fluently and accurately transfer conceptual knowledge to new problems.

Use of concrete examples requiring students to apply course concepts is central to the TBL course structure and pedagogy. Each TBL AE requires teams to consider a "significant problem" and make a specific choice that they must defend in a class-wide discussion with economic reasoning. The best AEs call on students to think like experts and contain multiple defensible answers. For example, a significant economics AE might center on expanding unemployment benefits during a recession and highlight theoretical and empirical debate within economics over the extent to which such benefits discourage those who have lost jobs from seeking new employment. According to Roberson and Franchini (2014, 295), "[s]tudents' passive familiarity with abstract concepts will be converted to active understanding only when it is applied and tested at the level of concrete, specific scenarios that evoke the abstractions."

A sequence of increasingly complex AEs is used throughout each module of a TBL course, with numerous opportunities to apply abstract concepts to real-world examples, increasing the likelihood that students will be able to transfer the economic concepts and models to new and unfamiliar situations (Chew and Cerbin 2021, 12). Moreover, TBL includes an instructor-led debriefing session following each AE to ensure that students understand how the example highlights a more general principle or concept. This intentional linking of real-world examples to abstract economic concepts by the instructor is supported by learning sciences research, as illustrated in the findings by Rawson, Thomas, and Jacoby (2015) cited above. Additional AEs or assessments, such as homework problem sets, can further reinforce this deeper understanding that extends beyond the example itself.

Strategy 5: Blending Appropriate Sequencing of Direct Instruction (Lecture) and Student Exploration

The learning sciences literature offers strong evidence that in order to best support student learning, direct instruction or lecture should *come after* student engagement with an idea or concept (Schwartz and Bransford 1998; Schwartz et al. 2011). In other words, the typical classroom practice should be reversed. Instead of first lecturing about a concept and then demonstrating its validity through an active learning exercise, it is better for students to explore the topic in a structured manner before direct instruction. This learning sequence is also recommended by Chew and Cerbin (2021, 10) as a way of identifying and addressing misconceptions.

Starting with structured exploration helps students understand the problem to be addressed – why there is a need to investigate the concept and why a student's initial conceptions might be incorrect or insufficient. Psychologist Daniel Schwartz calls this approach a "time for telling" (Schwartz and Bransford 1998; Schwartz et al. 2011) or "just in time telling" (Schwartz, Tsang, and Blair 2016). Similarly, Brown, Roediger and McDaniel (2014, 101) conclude that "Trying to come up with an answer rather than having it presented to you, or trying to solve a problem before being shown the solution, leads to better learning and longer retention."

Team Based Learning creates two places in which a "time for telling" occurs. The first is straightforward: if the team Readiness Assurance Process reveals consistent errors on a question, this is a propitious moment for the instructor to address the issue in a short mini-lecture. The second type of "time for telling" follows each AE. The best AEs invite student discussion about the pros and cons of several answers. By carrying out this structured discussion, students apply newly learned concepts in new contexts, revealing the relevance of those concepts and the student thinking processes they uncover. The instructor can use the student interaction in the inter-team discussion to identify key points that need further explication in a mini-lecture to close the exercise.

Strategy 6: Integrating Highly-Structured Group-Based Activities Throughout the Course

Learning sciences research points to the need for careful attention to structuring group-based interactions (Slavin 2012; Davidson and Major 2014). Simply putting students in groups and expecting learning to take place can in fact be counterproductive (Cooper 2009, 207-210). Davidson and Major (2014, 29) note that in three prominent group-learning pedagogies at the college level (cooperative learning, collaborative learning, and problem-based learning) student groups have:

1. a common task or learning activity suitable for group work
2. small-group interaction focused on the learning activity
3. cooperative, mutually helpful behavior among students as they strive together to accomplish the learning task, and
4. individual accountability and responsibility.

Team-Based Learning puts into place these four recommendations for structuring effective group work in systematic and intentional ways.

Engaging Teams with Group-worthy Tasks

Evidence from the learning sciences supports the use of group-worthy tasks (Schwartz, Tsang, and Blair 2016, 144) in which the team accomplishes more than any individual could do alone. In TBL, both the tRAT and AE processes pose students with such tasks. With points on the line, tRATs promote team interaction and feedback before scratching off the team's selected choice on the IF-AT card. Note that the tRAT almost always results in higher scores than any individual earned on the iRAT (Michaelsen, Watson, and Black 1989). More important, AEs engage students with a significant problem that has specific choices. Effective AEs provide a set of choices that may be drawn from well-known student misconceptions or reflect theoretical or empirical debates in economics; typically, AEs provide sufficient ambiguity to make easy selection of a single answer challenging, generating valuable team discussion. Good AEs require insights from all team members and focus all team members on specific concepts that the instructor has chosen as most important.[6]

Focusing Team Interaction on the Learning Activity

TBL provides a course structure in which students intentionally, systematically, and repeatedly engage with one another in meaningful, highly-structured learning activities. In particular, AEs promote focused team interaction: first, through the careful design of the *exercises* that intentionally structure team discussion around a small number of choices (rather than open-ended questions that could take the team on wide-ranging discussions); and second, through the *structured process* of the activity itself.[7] As noted earlier, the structure of the AE activity, with all team members accountable for defending the reasoning of their team's choice in the AE, promotes elaborative interrogation and self-explanation (see Schwartz, Tsang, and Blair 2016, 234-246) of important course concepts and encourages students to make "connections to their own knowledge" while simultaneously promoting formative assessment of their understanding (235) as they interact with team members. In TBL, most class time is spent on such focused self-explanation through AEs. In contrast to full class discussion in which one student speaks at a time, structured team-based work promotes simultaneous student talk, greatly magnifying the time in which each student can engage in this powerful learning strategy.

Promoting Effective Teamwork

Through intentionally structured permanent teams and group-worthy activities, TBL promotes the development of effective collaborative skills among students. Following recommendations from the cooperative learning literature (Cooper 2009, 207-210; Millis and Cottell 1998, 50-53), TBL features instructor-formed teams that last throughout the entire course. When making teams, instructors seek to combine students with different academic backgrounds, social groups, and life experiences with the purpose of promoting a diversity of perspectives (both within and across teams) and creating a learning environment that intentionally encourages inexperienced students to engage in meaningful work with other students in mutually beneficial ways. Incorporating challenging AEs that require the skills and perspectives of multiple team members increases the potential for learning with understanding rather than rote memorization of facts and concepts.

During a TBL course, repeated practice with tRATs and AEs offers regular hands-on practice in working together as a team. These activities, supported by regular monitoring and direction from the instructor and formative evaluations from peers, promote equal participation by all team members, counter-acting dominance by one student and free-riding by the others (Kagan 2014).

Embedding Student Accountability

Slavin (2014) highlights individual accountability as one of five key practices for ensuring successful cooperative learning. According to Slavin, individual accountability "is the essential element most often left out of cooperative learning – and when it is, teachers lose a lot of cooperative learning's potential." Slavin (1983), in a meta-study of a wide variety of cooperative learning methods, provides convincing empirical evidence that individual accountability is critical for increasing student learning. Ruder, Maier, and Simkins (2021) detail how TBL incorporates a "high level of accountability for student efforts to prepare outside of class and to contribute productively to team in-class discussions" by design. The Readiness Assurance Process, with its iRAT and tRAT sequence, encourages students to spend time engaging with preparatory material for a TBL module, as a portion of their course grade, along with that of their teammates', is determined by their performance on these quizzes. Similarly, the random nature of team reporter selection for AE report-outs provides additional incentive and accountability for engagement in team activities. Slavin (2014) identifies choosing a random reporter as an effective way to reduce free-riding and ensure that group learning pedagogy leads to increased student achievement.

In addition, TBL intentionally builds in both formative and summative peer evaluation that promotes effective team functioning. Including formal teammate evaluation (see, for example, LearnTBL: Developing a Peer Evaluation Plan 2018) as part of the course grade in TBL classes holds students individually accountable for their team participation, providing an incentive for each team member to come to class prepared, contribute to team activities, and provide feedback to other team members. Midterm formative peer assessment of team members' contributions promotes mid-course opportunities for students to modify their learning practices to keep teams functioning at high levels throughout the semester.

SUMMARY

TBL has significant potential for enhancing student learning in economics courses by putting into practice well-established, evidence-based recommendations grounded in learning sciences research. The formal, whole-course structure of TBL, with a systematic, repeated cycle of learning that includes a Readiness Assurance Process and AEs within each module, continually reinforces students' learning in a systematic and intentional way, informed by learning sciences research. What makes TBL a potentially powerful teaching/learning strategy is the *combination* of these learning science strategies embedded in a comprehensive course design.

TBL offers economics instructors a valuable research-based instructional strategy that has been shown to be effective at improving student learning and engagement in a variety of disciplines. We believe that by paying close attention to the learning sciences principles outlined here, instructors using TBL can do the same in economics. We encourage economics instructors to take advantage of the extensive TBL resources at the *Starting Point: Teaching and Learning Economics: Team-Based Learning* website (Simkins, Maier, and Ruder 2018), created to lower TBL start-up and implementation costs, to examine the role that TBL can play in their own courses and to carry out additional research evaluating its impact on student learning in the economics classroom.

NOTES

[1] Chew and Cerbin (2021) recently provided a useful cognitive framework for economics instructors, grounded in "nine cognitive challenges that teachers need to address in order to help students learn" (3) that aims to increase the use of learning sciences research findings in course design and pedagogy. The cognitive challenges they list (Table 1) complement the six learning-sciences-based teaching strategies highlighted here; their recommendations for addressing those challenges include a number of teaching strategies discussed in this paper.

[2] Readers unfamiliar with TBL will benefit from reading Ruder, Maier, and Simkins (2021), who provide an overview of TBL course design, assessment, and activities, before reading the current article.

[3] As McGoldrick and Garnett (2013) note, a variety of teaching practices can be used to promote learning with understanding through the use of context-rich, real-world problems, such as cases, a social issues course design, or carefully crafted Socratic discussion. A critical component in the "big think" approach is the careful crafting of the underlying learning exercises. The four "foundational criteria" for learning modules presented by McGoldrick and Garnett are complementary to TBL pedagogy, in particular the Application Exercises that make up the bulk of a TBL course.

[4] This is also related to the importance of incorporating "desirable difficulties" into the learning process to promote learning, as discussed in Bjork (1994).

[5] Immediate Feedback Assessment Technique (IF-AT) forms are available from Epstein Educational Enterprises (2021). See Calimeris and Kosack (2020) for a detailed discussion of the IF-AT instrument and previous research on its efficacy in promoting student learning.

[6] Creating effective AEs with these characteristics is perhaps the biggest challenge for instructors starting out with TBL. The online *Starting Point: Teaching and Learning*

Economics pedagogic portal (Maier, McGoldrick, and Simkins 2012), includes an extensive library of curated AEs covering a wide variety of economic topics (https://serc.carleton.edu/econ/tbl-econ/activities.html) that economics instructors can adopt or adapt for their own classes.

[7] See Ruder, Maier, and Simkins (2021) for details on the design of effective Application Exercises and their use as part of the TBL teaching strategy.

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