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WEB PAPER
AMEE GUIDE

Team-based learning: A practical guide: AMEE Guide No. 65

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Abstract

Team-based learning™ (TBL) is an instructional strategy developed in the business school environment in the early 1990s by Dr Michaelsen who wanted the benefits of small group learning within large classes. In 2001, a US federal granting agency awarded funds for educators in the health sciences to learn about and implement the strategy in their educational programs; TBL was put forward as one such strategy and as a result it is used in over 60 US and international health science professional schools. TBL is very different from problem-based learning (PBL) and other small group approaches in that there is no need for multiple faculty or rooms, students must come prepared to sessions, and individual and small groups of students (teams) are highly accountable for their contributions to team productivity. The instructor must be a content-expert, but need not have any experience or expertise in group process to conduct a successful TBL session. Students do not need any specific instruction in teamwork since they learn how to be collaborative and productive in the process. TBL can replace or complement a lecture-based course or curriculum.

Introduction

What is team-based learning?

Team-based learning™ (TBL) is an active learning and small group instructional strategy that provides students with opportunities to apply conceptual knowledge through a sequence of activities that includes individual work, teamwork and immediate feedback. It is used with large classes (>100 students) or smaller ones (<25 students), incorporating multiple small groups of 5–7 students each, in a single classroom. TBL is specifically characterized by three key components:

- individual advance student preparation;
- individual and team readiness assurance tests (tRATs); and
- the majority of in-class time devoted to decision-based application assignments done in teams.

TBL is highly learner-centered (yet has critical faculty input) and uses grading, peer evaluation and immediate feedback to ensure individual and team accountability to promote learning and, unlike other group-based instructional approaches, one content-expert instructor can instruct 20 or more teams.

TBL is used in over 60 US and international health science professional schools, including medicine, dentistry, veterinary medicine, nursing, and allied health disciplines, at several levels of training: undergraduate, postgraduate, and continuing professional education.

When TBL is conducted correctly, there is little question that academic outcomes are equivalent or improved in comparison to either lecture-based formats or more traditional small group learning models (McKiernan 2003; Levine et al. 2004; Koles et al. 2005, 2010; Shellenberger et al. 2009; Zgheib et al. 2010; Thomas & Bowen 2011).

Unlike typical group learning, the high performers do not suffer – by either having to do all the work or poor performers dragging their scores down. The process holds everyone accountable for their own individual work and the individual's contribution to their team. The better a team works together, the better their team and individual scores. Extensive peer teaching occurs within each team.

Faculty may fear that the team scores mask the underperforming student. In reality, TBL provides more data, earlier, about an individual's weaknesses and permits team members

Practice points

- TBL is a learner-centered, instructor-directed strategy for small group active learning in large group educational settings.
- Learners are *accountable*; expected to prepare outside of class and collaborate with their team members to solve authentic problems and make decisions in class.
- Only one content-expert instructor is needed for the whole class in one room.
- Students learn how to work in teams through the process of TBL – they do not need additional instruction nor does the instructor need be a group process expert.
- A backward design, outcomes-based approach is used to stay focused on what the learners should be able to do.
- One must use TBL's key components and follow the process for TBL to be successful.

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and faculty to provide help long before a summative exam. In addition, it is not as though individual performance is mitigated – it is transparent and visible – and the final grade for a student is derived from both the individual's and the team's performance.

Why the need for this Guide?

The use of TBL in health professions education is rapidly growing for at least four key reasons: One is that administrators are pushing for classes to be larger (more revenue) but want them to be taught in ways that are active, engaging, and promote positive learning outcomes.

Two other reasons are that accrediting bodies are also requiring documentation that schools are: (a) employing "active learning" (Liaison Committee on Medical Education 2011) and (b) equipping students with the skills they will need to work in team-oriented environments (Interprofessional Education Collaborative Expert Panel 2011).

Finally, faculty are frustrated that fewer and fewer students attend their lectures (especially in programs where the lectures are recorded) and students give "mixed messages" about how they want to learn: "spoon feed us with detailed lectures and notes for what is on the exams" and/or "don't bother to lecture to us what we can learn online – bring us to class when you can guide and challenge us to think and solve problems."

What is the purpose of this Guide?

While many faculty implementing TBL are using the key principles and achieving partial or great success, some are using only "bits and pieces" of the strategy with mixed success or even failure. With this Guide, we hope to do the following:

- Clarify what TBL is and is not, when and how it should be used, and which of its components must be done (and how) for the greatest likelihood of success.
- Entice those who are still lecturing to consider doing something different and more professionally satisfying because you get to see the students engage in solving real-world clinical practice problems – the shift can be exhilarating.
- Challenge those using problem-based learning (PBL) or other small group learning activities to either add TBL to their teaching repertoire or adopt it instead.
- Generate innovative ideas and projects for collaborative scholarship within the growing learning community of TBL practitioners.

How was TBL developed?

Michaelsen when a professor of Business at the University of Oklahoma, developed the TBL strategy in response to increasing class sizes and his discomfort with lecturing and not knowing if, what, or how his students were thinking during his presentations. In addition, he feared that if students did not have regular opportunities in class to struggle with the kinds of problems they would face in the business world, the classes would be a waste of time.

How has TBL evolved?

During the 1990s, in the USA, TBL became known and practiced in undergraduate (college-level) business schools and within other disciples in undergraduate settings. In 2001, the US Department of Education Fund for the Improvement of Postsecondary Education provided funding to the Baylor Medical College in Texas to promote TBL in health professions education through faculty development workshops, symposia and the scholarship of teaching and learning. This grant spawned the adoption of TBL at many US and international medical, nursing, veterinary, dentistry, and allied health schools over the next several years, though the amount of its use at each institution varies considerably (Thompson et al. 2007a, b). The grant also supported the creation of the TBL Collaborative – a broad-based, mostly higher education, consortium that has a resource-rich website (www.teambasedlearning.org), sponsors an annual meeting with international attendance, qualifies faculty members to conduct workshops in TBL, and promotes scholarship on its efficacy, best-practices, and innovations.

What are the essential components of TBL?

We have divided this section into two parts:

- Part 1: focuses on what learners will experience in a TBL session.
- Part 2: is a step-by-step set of recommendations for instructors on how to construct and deliver a TBL module.

Part 1: What does the learner experience?

TBL's sequence of steps is Forward Thinking; guiding students into thinking progressively and gaining the ability to look beyond the "now" and constantly asking, "what's next?"

TBL sequences the learning process for the students through the following steps, as visualized in Figure 1.

Students' perspective

TBL recurring steps

Step 1 – Advance assignment.
Out-of-class/individual. Students receive a list of learning activities, accompanied by a set of learning goals. Students study materials in preparation for the TBL session. Learning activities may include readings, videos, labs, tutorials, lectures, etc.

Step 2 – Individual readiness assurance test.
In-class/individual. Each *individual* student completes a set (10–20) of multiple-choice questions (MCQs) that focus on the concepts they need to master in order to be able to solve the Team Application (tAPP) problems.

Step 3 – Team readiness assurance test.
In-class/team. This is the *same* set of questions that each student has answered individually! But, now the *team* must answer them through a consensus-building discussion. There must be a mechanism so that the team knows as-

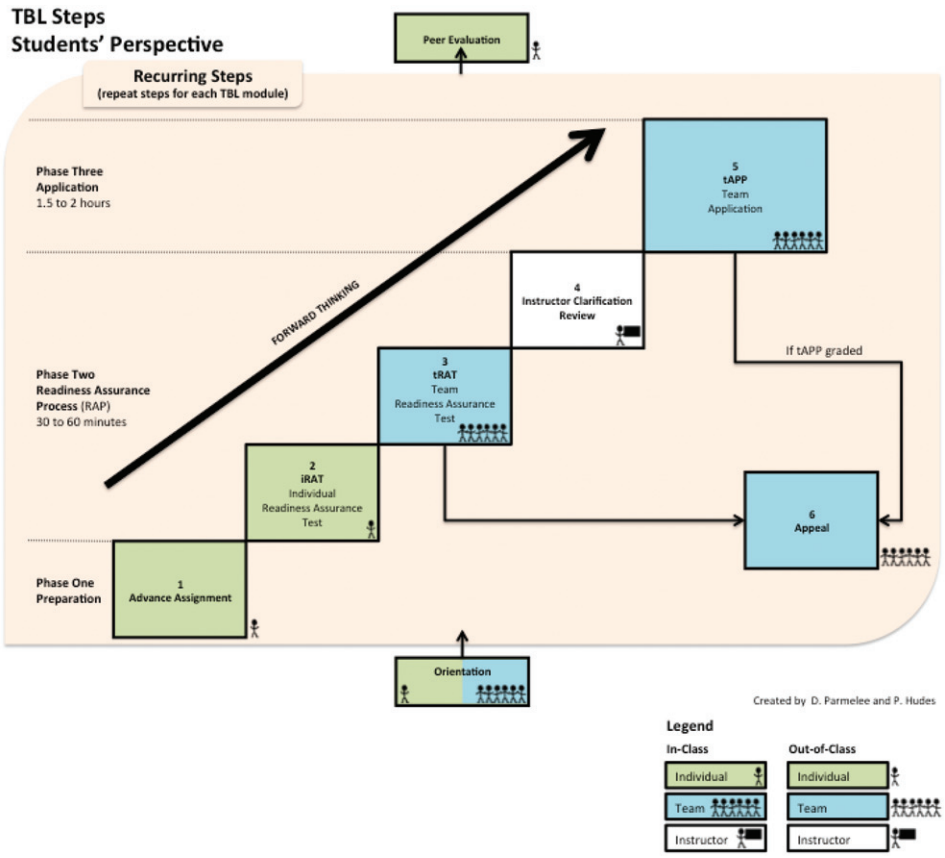

Figure 1. TBL steps – students' perspective.

immediately-as-possible whether or not they have selected the correct answers because they need this immediate feedback to help them improve their decision-making process.

Step 4 – Instructor clarification review.
In-class/instructor. Students are given clarification from the instructor on the concepts they have been struggling with during the tRAT. At the end of the Clarification Review, students should feel confident that they are adequately prepared to solve more complex problems for the next TBL step: the Team Application.

Step 5 – tAPP – Team application.
In-class/team. This is the most important step! Students, in teams, are presented with a scenario/vignette that is similar to the type of problem that they will be grappling with in their careers. They are challenged to make interpretations, calculations, predictions, analyses, synthesis of given information and make a specific choice from a range of options, post their choice when other teams post theirs, then explain or defend their choice to the class if asked to do so.

The tAPP's structure follows the *4 S's principles:*

- *Significant problem.* Students solve problems that are as realistic as possible. Problems must authentically represent the type of problem that the students are about to face in the workplace or are foundational to the next level of study. The answers must not be able to be found in any source (internet, textbook), but can only be discerned through in-depth discussion, debate, dialogue within a team.
- *Same problem.* Every team works on the same problem at the same time. Ideally, different teams will select different options for answers.
- *Specific choice.* Each team must make a specific choice through their intra-team discussion. They should never be asked to produce a lengthy document. Teams should be able to display their choice easily so that all teams can see it.
- *Simultaneous report.* When it is time for teams to display their specific choices to a particular question, they do so at the same time. This way, everyone gets immediate feedback on where they might stand in the posting and they are then accountable to explain and defend their decision.

Step 6 – Appeal.
Out-of-class/team. A team may request that the instructor consider an alternative answer to the one designated as "best." The team must either provide a clear and usable re-write of the question if they think it was poorly worded, or a rationale with references as to why their choice was as good as the "best" chosen by the instructor. Only a team that takes the steps to write an Appeal is eligible to receive credit for a particular question.

TBL non-recurring steps

Orientation.
Out-of-class/in-class/individual/team. Students read a brief article about TBL, out-of-class, in preparation for the orientation session, or the course syllabus as the first Advance Assignment. In-class, students take an individual readiness assurance test (iRAT) individually, followed by a tRAT in teams

and then the tAPP that covers the essential principles of TBL. The instructor clarifies TBL concepts, including how TBL is different from students' previous learning group experiences.

Peer evaluation.
Out-of-class/individual. Each student must evaluate each of his/her teammates on their contributions to the team's success and their own learning. It is best if there is both a quantitative and a qualitative component in which they get practice with framing constructive feedback to one another. It should be done anonymously, but team members are encouraged to speak directly to one another in providing feedback.

Student Quotes. For the purpose of this Guide and to bring the students in perspective, we think the best way to convey their experience is using a representative sample of quotes from course evaluations and urge instructors/readers to ask themselves the question:

> Are these things that I'd like to have my students say about their experience in my course?

First, we share three quotes that reflect common but, quite different, themes related to students' overall experience in a well-designed and managed TBL course:

- "I detest group work. Always have. But, this is different. Everybody is accountable."
- "I learned more from my peers than I could have learned from the professor. We argued a lot and this was a good thing."
- "Instead of being tested on minutia, the Application questions forced us to really understand and apply all those details."

Next, we share several representative quotes about each of the three major components of TBL. Again, we urge instructors to ask themselves, "How would I feel if students felt this way about the things they are learning from each of the major components of the teaching strategy that I've been using?"

Advance assignment.

> "The advance assignment states what has to be mastered before each TBL session, and it is pretty specific, like "Review the three lectures on Liver Anatomy & Physiology plus read Chapter 14 in Robbins." In addition, I make a checklist from the objectives for that session so that I'm pretty sure I know what I need to know. We've all learned that the more effort you put in on the front end of a TBL session, the more you get out of it. It's a ton of work if you do it right. Our team does not meet outside of class to prepare, but some do. It's nice that a team does not have to meet outside of class since that can be such a hassle. But, we made a commitment early on to always come prepared."

Readiness assurance process.

> "The first time I took an iRAT, I got creamed. I thought just a good skimming of the material, like you do for a lecture, was all that was necessary. The questions were right out of the assignments, but they were hard and more detailed than I imagined. Ouch. In my team, a couple of us were not well prepared, and it was embarrassing; we had to admit it to our teammates. The others were on top of the material and had even read more than assigned. Scary. It didn't happen again to me because I learned how much work was needed to come to class ready.
>
> After the iRAT, that first time, we went through each question as a team, voting for which one was best, then selecting based on the majority vote. We were doing the IF-AT scratch-off form (see explanation later), something none of us had ever done before, and we did not do as well as many of the other teams in the class. It was nice to be able to scratch again if we got one wrong, but, we learned that to get more of them right on the first scratch, you really have to achieve a consensus – and this means really talking through the questions and the options carefully. Voting is a risky short cut. As the semester wore on, we voted less and less, argued more and more to be sure our team was heading for the top.
>
> When we felt strongly about one of our selections, and it was wrong by the scratch-off form, we could bring it up for a whole class discussion, hoping for the instructor to say "You're right. That's a great explanation; I may accept this is a correct answer as well." Usually, the teacher would get another team to say what they heard as wrong with our position. There were some pretty heated discussions around the RAT questions and it was a nice feeling when the teacher granted an appeal.
>
> The single best thing about the RAT is that you know whether or not you are getting the content down – always important when you think about the boards! Besides, if you don't get it down well, you become lost on the Team Application questions because they are so much harder. The single worst thing about the RAT is if the questions are poorly written and do not link to the Advance Assignment, then we all get frustrated and mad. Fortunately, our instructor always took time before moving on to the Team Application to let us know what we still needed to think about and study further."

Team application.

> "This part of TBL makes or breaks the experience. We like it best when:
>
> - there's a time limit. Please don't keep us in a room more than 2½ hours, 3 at a real max;
> - the instructor keeps the whole class discussion/ defense of answers moving along – sometimes, people can drone on;
> - the case scenario feels real to us, and the questions are about important things – we can tell! When it's over,

we have to leave the room feeling that we learned how to think better about the topic. Amazingly, on these really hard ones, there were always a couple of teams that figured out the best choice and had perfect explanations!

- Here again having the ability to appeal an instructor decision is good; twice we appealed with excellent documentation and got the points with a compliment!

The hardest thing about the Team Application? Sometimes, we were expected to know some clinical thinking that we just weren't ready for, but, if the instructor explained it well in the wrap-up, then we felt we were stretched, but we learned.

The other hard thing was being called upon to stand up and speak for the team. Many of us had fears of public speaking, but the rule was that the instructor would always select randomly someone by name from a team to explain the team's decision. So, you had to always get yourself prepared to do the explaining: you could not expect the good speaker in the team to do it."

Part 2: What does the instructor have to do?

The instructor must create a TBL module in the reverse order, using a process called Backward Design (Wiggins & McTight 1998): a three-stage design process that delays the planning of teaching and learning activities until clear and meaningful learning goals have been defined and feedback and assessment activities designed (Figure 2).

Figure 3 demonstrates the steps to design an effective TBL module.

Instructor's perspective

TBL recurring steps

Step 1 – Situational factors and learning goals. Identify important *Situational Factors*, e.g., students' prior knowledge. Then, write clear, specific and meaningful *Learning Goals* that answer the question "What do I want my students to be able to do at the end of the session that they could not do before?" Be specific with exactly how well you want them to master this – use action verbs such as identify, list, explain, calculate, compare, analyze, etc.

Step 2 – tAPP – Team application. After you have established learning goals for your TBL session, you need to create or find a problem case or scenario that is authentic and believable, the kind of brief story that your learners can relate to and know that this is the sort of situation that they will soon encounter in their profession.

In the health professions, such cases often come with important data that need interpretation in the context of the case. Include enough to enable them, but do not give them so much that they end up being overwhelmed. You want the learners to be able to evaluate and analyze the manifest

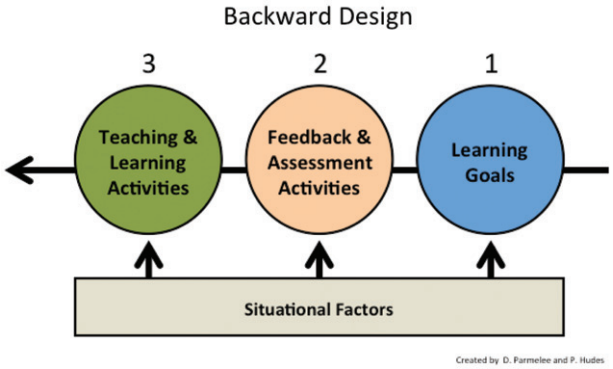

Figure 2. Backward design process.

features of your problem with the data and make decisions about the questions you pose.

Never ask them a question for which the answer is in a book or can be searched and found online (students are excellent web-searchers). The solution needs to be one that they can *only* get to the answer through their deliberations. Of course, it is perfectly OK to include elements in the presentation or data that they do not fully understand, and they must search their resources to master.

We recommend sticking with the 4 S's principles:

(1) *Significant problem.* The problem you select and the associated question(s) must be important, authentic, and truly representative of the kind of problem students are about to encounter in their professional activities.

Go for quality of questions and not quantity. There will be the tendency to try to ask too much in the Team Application, fearing that you need to "cover" so much content. Trust the process: if you design questions that really make students think and struggle with making a decision about something *significant*; they will master the content and key concepts.

(2) *Same problem.* All teams must be working, in class, on the same problem at the same time.

Commonly, with in-class, small group exercises, each group is given a different problem with the expectation of a sharing process at the end. This is a "killer" experience for the students for two reasons. One is because they have to endure listening to other groups present their "findings," and once they present their own, they will not pay attention to anyone else's. The other is that, having teams on different problems largely eliminates inter-team accountability. At best, you are likely to get a polite question or two because their motivation is low and, in addition, students are likely to feel they do not have the information they need to mount a credible challenge.

(3) *Specific choice.* Craft questions that truly probe the "why" of a concept or use a set of data for interpretation – this separates excellent teaching from mediocre. When the learner must discern between several equally plausible options, select the BEST one and prepare to defend that decision, there is deep learning.

With TBL, by listening in to how students are processing your questions and determining the BEST specific choice, you

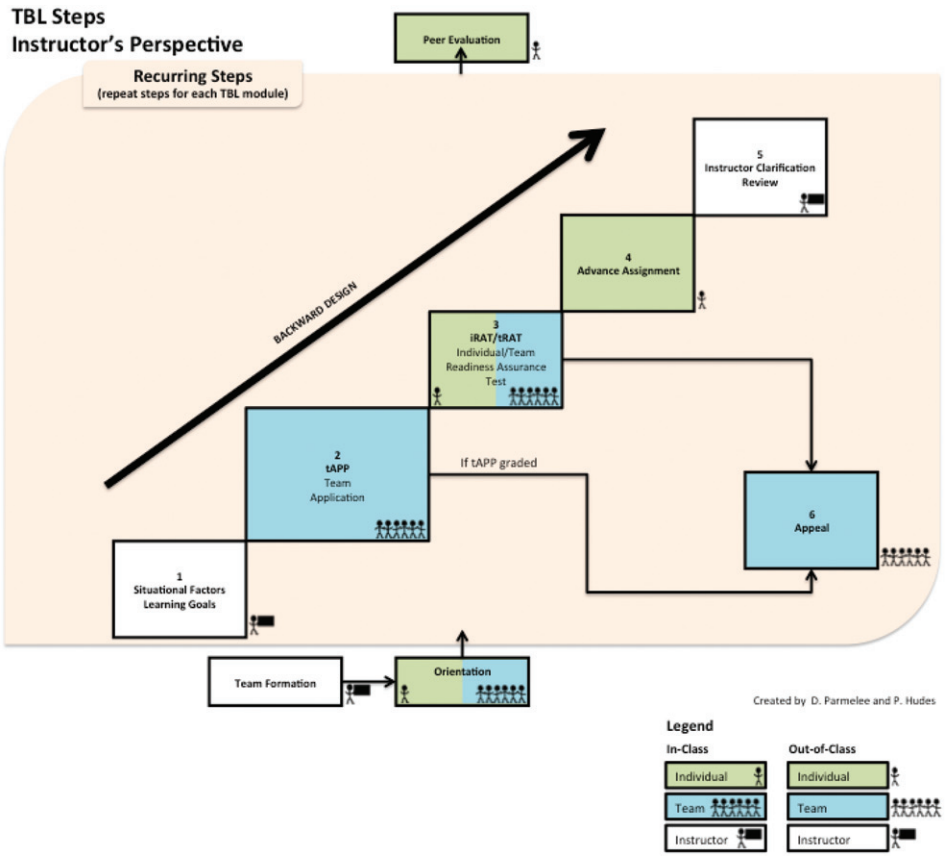

Figure 3. TBL steps – instructor's perspective.

know how they are thinking. When a team member passionately defends her team's selection against countervailing positions, whether she is wrong or right, you know that you have a "teaching moment."

Some instructors feel they are excellent teachers when students applaud after a lecture. But, at what point during the 50 min do you really know how students are thinking about the concept you are teaching? When do you know if they can apply that concept to a novel situation/problem? At the exam?

(4) *Simultaneous report.* A key to energizing team discussions is using procedures that make teams accountable for reaching and being prepared to defend a decision. Having teams work on the same problem is essential for intra-team accountability but it is not enough.

Instructors often reduce accountability in one of two ways. First, students discover that you have a pattern of calling for volunteers (e.g., "which team would like to give their answer?"). Students know that it is pretty safe to sit back and let the other teams risk giving what might be an incorrect answer. Second, if your practice is to randomly call on one of the teams to give their answer, students' motivation to "get it right" is significantly reduced by their realization that, even if they do not have an answer, they have two minimally embarrassing options. If they are the "unlucky" team that gets called on first, they can say, "We haven't had time to reach an agreement and, if they aren't the first team to be called on, they can say, 'We agree with team ___' (i.e., the team that reported first)."

With TBL, however, teams are fully accountable because students are informed from the beginning that all of the teams will have to report their answers *at the same exact moment and their task is to make a decision and be prepared to defend it.* As a result, the interaction during the Team Application follows a distinct pattern. When the learners first begin grappling with the problem, there is often quiet in the room as they read and ponder individually for a few moments, then a low-grade "buzz" starts as members of teams start sharing their impressions, raise questions, and assign searching tasks to one another – in short, enjoin a strategy for making a decision within the timeline of the exercise.

When time is called for the posting of all decisions, teams simultaneously post their answers for all to see (e.g., by displaying a numbered or lettered card, putting up a poster, using Audience Response System "clickers," etc.).

If the Team Application case and questions have been written well and are tightly linked to the learning goals and the readiness assurance process (RAP), then, it is rare that a team will have questions for the instructor during the time they are trying to reach a decision. As the instructor, your task is to roam around the room and listen in on the team conversations and learn how they are processing the assignment, remember what you hear and use it in the class discussions to follow. Unlike any other small group work, the requirement that each team must make a decision on the same difficult question, and be in competition with other teams, generates a great deal of noise and animation in the classroom. The better your

questions, the more lively the room becomes until the time for posting decisions.

Once the teams' decisions have been revealed, your job is to use the teams' simultaneous reports as a catalyst for facilitating the inter-team discussions. What are the ways to facilitate the class discussion, generating dialogue and debate between teams? Go for the "Why?": "Why did your team make this decision?", "Explain your thought processes." To a different team with a different answer: "Let's hear your rationale, why is it better than what we have just heard?" If there are many teams in the classroom, it is not necessary to get an oral defense from each team – this may bore the others and be too much like the usual small group work project sharing.

Some facilitation tips:

- When you call on a team to explain, select a specific student from a random list sheet or use *Teacher's Pick*™, an APP for the iPHONE or iPAD (http://itunes.apple.com/us/app/teachers-pick/id320221052?mt=8) – do not ask for a representative of the team to speak because the team's extravert will always do it.
- Make a rule that anyone who speaks to the whole class must *stand up* or use a microphone, and get in the habit of moving *away from* the student who is speaking so that he/she will speak louder.
- At first, the speaking student will try to talk to you since you asked the question. Inspire them to speak to the other teams, not you. Remember: your *teaching moments* are framed by the questions you ask about their decisions, their thought processes; save your own conclusions about the question until they are all in suspense about the "best" decision, then explain using what you have heard in their propositions.
- Before the session, review each of your readiness assurance test (RAT) and Team Application questions with this checklist:
  - What is the key learning point from this question?
  - Where would the student have been exposed to the information needed to answer it?
  - What if all teams get it right? Do I move on to the next question? Do I give them a few more minutes to post what they think is the "Second Best Answer"?
  - What if all teams get it wrong? How will I show them my thinking about what I selected as the right answer?

Step 3 – Individual readiness assurance test/team readiness assurance test. Preparing the Team Application (tAPP) first, enables you to design RATs that truly prepares the learners for the tAPP – you know what they need to know to apply the content to meaningful problems. The questions should be in multiple-choice format (MCQ) and they should be well constructed so that their quality is equivalent to your end of course/term or licensing examination. A great source for writing effective MCQs is the National Board of Medical Examiners *Item Writing Manual*, downloadable at their website (www.nbme.org/publications/item-writing-manual.html).

How many questions you prepare depends on the amount and complexity of the content, and how much time you have in your course design for TBL. On the one hand, you do not want to overwhelm the learners with lots of MCQs where they feel they are always studying to take a test, but you and they do want to have regular assurance that they are mastering the content and that the work they have done preparing is important by being assessed.

Another key is that the questions should focus on the big ideas not the details. If they really understand the big ideas, they are prepared to learn the details when they try to use them to make the decisions that are part of the Team Application.

There are two parts to the RAT: *individual* and *team*. Learners take the iRAT at the beginning of the session, recording their decisions using a Scantron™ or Audience Response System "clickers."

When time is up, teams cluster and answer the exact same questions as a team, with the tRAT, making their selections on an Immediate Feedback Assessment Technique (IF-AT™) form. The IF-AT is a multiple-choice answer form with a thin opaque film covering the answer options. Instead of using a pencil to fill in a circle, students scratch off the answer as if scratching a lottery ticket. If the answer is correct, a star appears somewhere within the rectangle indicating the correct answer. Students earn partial credit for a second attempt and learn the correct response for each question while taking the tRAT. One member of a team is picked by the team to do the scratch off on the IF-AT form, and all are at rapt attention as he/she determines whether or not the team's decision on a question is the preferred one. Generally, teams will give out a small cheer when right and a light groan if wrong. If they do not get it right the first time, they will immediately re-engage on that question and make another selection, but not without careful consideration since the stakes are higher. More information about the IF-AT form is available at the Epstein Educational Enterprises website (www.epsteineducation.com).

Always structure time for the discussion of the RAT after the team process, and when you use the IF-AT, encourage teams to select the one or two questions that they would like the whole class to discuss. Although they know your designated "correct" answer from the IF-AT, if you crafted the questions well, then there should always be two to three questions that really challenged them and they will want to discuss, or even appeal (see step 6 – Appeal).

We strongly recommend using the IF-AT in the tRAT. These are our reasons:

- Whether it is the very first gathering of the team or the last in a course, the tRAT forces them to share what they have learned as they *each* explain why they support one answer over another. Because conflict is uncomfortable, brand-new teams will initially make their choices by voting. However, with time (and the IF-AT form speeds up the learning process) they learn that voting is risky and it is more effective to share explanations first, then discuss their way to a consensus.
- The IF-AT promotes team cohesion – when the team makes its decision and scratches off the selected option on the IF-

AT, everyone is paying acute attention: if they have drifted apart physically during the discussion, they move back in; if they are separated by a table, they lean in – everyone wants to see and they will need to get closer to do so.
- If a team "gets it wrong" the first time, they immediately explore *why* so that they can select the "right" one next, and they are motivated to do so since they will still get partial credit.
- Learners who tend to be overly assertive will inevitably be wrong on one or more of the questions. When this happens, the pushy student will become more cautious and the peers will be more willing to advocate for further considerations of an answer. Or, a learner who usually "goes along" with the crowd will eventually be put on the spot and asked to defend their choice – in effect, be encouraged to participate, especially if they have been correct and not helped the team get to the right answer.

Step 4 – Advance assignment. Prior to coming to class, the learner needs to know what he/she must read, watch or do to be prepared for class. This is where you, the instructor, provide "scaffolding" for their acquisition of the information (content). It works best to provide them, as far in advance as possible, what must be read or done and clearly identify the level of requisite mastery so that they can be successful. You should develop or select appropriate teaching and learning activities (readings, videos, labs, tutorials, lectures, etc.) for the Advance Assignment that are aligned with the iRAT/tRAT questions, are effective and sufficient for content coverage, and that include specific learning goals.

In the health sciences, there is an infinite amount of detail within many critical complex concepts. As tempting as it is to list all the content that they must learn and then test them on it in the RATs, it is far better to identify the *key* concepts and inform students what the concepts are and how they will be expected to apply them. For instance, autonomics is one of the most complex areas in medicine, and there are a great many agents whose names must be memorized along with how they affect different receptors. Your "scaffolding" lecture or tutorial clarifies the principles of autonomics, reviews the body's anatomic structures for sympathetic and parasympathetic systems, notes a few of the prototypical agents/transmitters, and leaves them with a handful of practice problems; the answers to be provided the next day or posted online. Memorizing the many agents that interact with the autonomic nervous system is a requisite task, like memorizing the multiplication tables, and doing so will "stick" better if done in the context of the "bigger picture" with as many practice exercises as possible.

Learners decide how they can best prepare: some study alone, some will form a study group, and some will use their class team as a study group. You do not have to recommend or suggest any; let them figure out what works for them as individuals and as teams.

After the first couple of TBL sessions, students will have determined how much time and energy they need to devote to the Advanced Assignment. Their scores on the iRAT, tRAT, and tAPP let them know how they are doing with the material as the course moves along.

Step 5 – Instructor clarification review. The RAP should include an instructor Clarification Review, in which students get clarification from instructor on the concepts they have been struggling with during the tRAT. At the end of the Clarification Review, students should feel confident that they are adequately prepared to solve more complex problems for the next TBL step: the Team Application. An effective Clarification Review predicts/addresses knowledge gaps (focused on the concepts that the students are struggling to understand), is neither a lecture nor a review of all concepts, and supports the development of critical thinking skills.

You should design the Clarification Review only after you have created the tAPP and RAT questions, since the purpose of the review is to better prepare students for the tAPP by addressing learning gaps identified during the tRAT.

Step 6 – Appeal. Teams should be able to Appeal a question in the RAP or the tAPP. If you accept their Appeal, then only that team is awarded the credit. There are two reasons for an Appeal:

- the team thinks that they were misled by the way the question was written and, to have the appeal granted, they must re-write it so that you agree that it is much clearer;
- the team is convinced that their answer is best and they can support this position through argument and/or valid source material which they reference.

Sometimes in the class discussion you hear an argument for an answer that is compelling, one you have not even thought about and, even though it is not normally done, you can award credit on the spot for their brilliance. More often, you need some time to process the arguments, as do the teams submitting appeals.

Keep the turn-around time as brief as possible and let the whole class know of your decisions. If the Appeal process is done in the spirit that everyone, including the instructor, can learn more, then it encourages more discussion and deeper learning.

A distinct advantage of a genuine process for Appeals is that you will not be sidetracked during the class by a few students who want to argue their position *ad infinitum*. It will allow them and you some reflection time and opportunity to better articulate a position.

TBL non-recurring steps

Team formation. Ideally, create teams that can stay together as long as possible. Sometimes this means for a year, a semester, or even a 4-week clinical rotation. There are four principles for assigning students to teams:

- Never let them self-select!
- Determine what you consider to be "wealth factors" in the class, for instance, previous work experience in healthcare or having an advanced degree in a health science field like biochemistry or physiology. Distribute all such students across different teams.
- Ensure that each team has as much diversity as possible. This is highly contextual and you must explore the potential characteristics in the class that represent diversity. For instance, if your school draws from a wide geographic area

that includes rural and urban settings, the teams will benefit from having members from both. Gender balance, if possible, is also desirable.
- Make the assignment process transparent. Students should never wonder how they were assigned to a particular team.

Orientation. For most students, TBL will be a new experience. The TBL Collaborative website has a link called "Orienting Students" with tips on how to introduce TBL to your students through a TBL sample session (www.teambasedlearning.org/Default.aspx?pageId=1032382). You can create the sample session using TBL content (based on a brief TBL article), or using the course syllabus as the first Advance Assignment.

Often the biggest hurdle is student attitude about preparing for class – so many are accustomed to coming to class to be told what will be on the exam, so why prepare for a class? With TBL, they must prepare using the Advance Assignment in order to pass or do well in the course. Classroom time shifts from being a time to transmit information to problem-solving with course content that is learned largely outside of class. This becomes very clear during the Orientation session.

Peer evaluation. There is little question about the importance of our students in the health professions learning how to give and receive constructive feedback from peers since they will need this skill set in the work setting with team members from several disciplines. We recommend the development of a process that encourages students to highlight the positive behaviors of their peers and develop the skills for constructive feedback. There are several viable models for conducting peer evaluation, all of which include:

- evaluation of each teammate on his/her contributions to the team's success and their own learning;
- both a quantitative and qualitative component;
- guidelines on how to provide helpful feedback.

For instance, for a qualitative query:

"What is the single most valuable contribution this person makes to your team?"

"What is the single most important thing this person could do to more effectively help your team?"

Grading. As with Team Formation, there are some principles for how to grade TBL:

- The percentage of time of a course that is devoted to TBL must be reflected in the course grade. For example, if it is a 12-week course and TBL is used for about one half of the contact hours, then it should count for about one-half of the final grade.
- Each component of TBL has a weight in the grading scheme and it will work best if the students have some responsibility in determining this within the limits you set.
- The peer evaluation should also count as part of the TBL grade.

An example of a TBL grading scheme would be:

iRAT = 25%
tRAT = 35%
tAPP = 35%
Peer evaluation = 5%

What are the TBL critical contextual factors?

Institutional culture

For TBL to be successful in a course or throughout a curriculum, it needs sanction if not support from the administrative leadership. Often, the simple support position of "classroom time needs to be used for solving problems and not just transmittal of information" goes a long way for faculty to consider using TBL.

Although there is good support in the literature for the effectiveness of TBL for a wide range of subject areas (www.teambasedlearning.org/refs), there are strong biases by faculty and administration against any active learning in the classroom. Some very experienced, and often talented, instructors grew up on the lecture-format and are wedded to it as the best way for students to learn – to be exposed to great minds such as theirs.

The administrative leadership may give in to these "sages on the stage" if they are large grant generating faculty whom they do not want to lose to the competition. In our experience, one faculty member or a small group of faculty can get started with TBL and generate both positive academic and student satisfaction outcomes within a couple of years. Students can become the best "salespersons" for having active learning in the classroom.

Faculty development

There are several steps that a group of faculty can take to make their transition to using TBL successful:

- Participate in several training workshops on TBL. If your aim is to have a few individuals experiment with TBL, have them attend the TBL Collaborative Annual meeting or equivalent venue. If your aim is to have a substantial part of your curriculum taught with TBL, you will need to bring one or more consultants to your campus first to introduce TBL to your faculty and later to help them refine their TBL course design and delivery.
- Once you have some pilot TBL courses up and running, establish a TBL learning community on campus or with neighboring institutions.
- Identify a consultant, someone experienced with TBL who can critique materials, observe initial sessions and help troubleshoot the problems that will inevitably arise.
- Peer-review all module materials, especially the MCQs in the RAP and the questions for the tAPP – this must include careful editing of the questions for grammar, syntax, and format, matching of module objectives to the materials, and framing of tAPP questions so that they will generate good, thoughtful discussions within and between teams.
- Ensure that TBL is an integral part of the course or curriculum design – it will flop if it is just plugged in without being well-linked to the other components (Fink 2003).
- Involve students, both to introduce them to how TBL works and get constructive feedback from them after a session.

Student buy-in

Students must have orientation to TBL, and there are several ways to do this.

At Wright State University Boonshoft School of Medicine (www.med.wright.edu), we have used the following:

- First day of class, give them the article "Three Keys to Using Learning Groups Effectively" (Michaelsen 1998) to read in class, then form teams, give them a iRAT and tRAT on TBL from the article, end with a couple of application questions about TBL.
- Before class, ask students to study the course syllabus, i.e., grading, attendance, papers due, key topics, exam schedule. At class, conduct a TBL session on the syllabus. After this first TBL session, make time at the end to review with them the objectives for the session and ask if they feel they met the objectives through the TBL experience.

At Duke/NUS Singapore (www.duke-nus.edu.sg/web), they conduct a TBL session as part of the medical student interview process; highlighting the value and benefits of TBL, the general process, and use it a bit as a marketing tool. Once students are accepted, they participate in a series of workshops that reinforce the process, the skills for team development, review of how study habits might change, and a practice session with a review.

Space/acoustics

TBL is very adaptable to a variety of space restraints, such as fixed seating in an auditorium. However, the best space is one in which students can easily cluster in either a small circle or around a small table. We say small table because we have seen the use of larger, eight to ten seat tables and students cannot get close enough to really "team;" besides, the large tables will have space for laptops and lots of references which get in the way of good team discussions. Remember: your Team Application problems can only be solved through discussion and deliberation, not a web search!

The ideal setting has a spot for the instructor in which he/she can see everyone in the classroom AND all students should be able to see each other. If a student can stand up, speak and be heard by all in the room, then you do not need an amplification system. The best amplification system has microphones at each table or cluster area; passing around a single mike can be cumbersome.

Why do we feel that TBL is an excellent instructional strategy for education in the health sciences?

The practice of medicine is rapidly changing in a number of ways that have a profound impact of the demands faced by medical educators in preparing their graduates for their future professional practice. The sheer volume of knowledge in every medical field is expanding and changing very rapidly. As a result, it is no longer practical or even possible for students to memorize everything they will need to know. Graduates now need to be grounded in the knowledge of their profession but, must also be trained and motivated to become life-long learners capable of accessing and assessing the wealth of information that is being discovered on an ongoing basis.

Similarly, the practice of medicine is increasingly becoming both inter-professional and team-oriented. Long gone are the days of the solo practitioner who can, by him or herself, master the breadth of knowledge that can and should be accessed and applied in diagnosing and treating patients. Safe and outcomes-focused patient care, whether ambulatory or inpatient, requires the coordinated efforts of practitioners from several disciplines as well as the patient and his/her family.

As a result, gone also are the days in which medical education programs can be satisfied if their graduates have successfully mastered the content of their courses. Current and future practitioners need to be able to both *use* the content and to be able to solve problems by working effectively with and accessing the combined knowledge of a diverse team of healthcare professionals.

Fortunately, TBL, when done well, addresses all three of these educational imperatives by nothing more than developing faculty members' ability to use their *content expertise* to design the feedback-rich learning experiences that make up TBL. A feedback-rich learning environment has a positive impact on content learning, which is characteristic of every phase of TBL.

Further, TBL prepares students for their future inter-professional work because the very heart of every phase of the process is using deliberately heterogeneous teams to solve numerous and varied medical-practice related problems.

Finally, unlike other group-based approaches that require educators to develop group process facilitation expertise, students in TBL courses develop interpersonal and team skills through real-time *content* feedback on how well they have used their members' expertise in making decisions. Irrespective of whether the feedback comes from an IF-AT form, other teams or from the teacher, students are never in doubt as to whether or not they understand the content *and* whether or not they have used members' knowledge resources in a positive way.

What are the outcomes to date and what are important questions to answer in the future?

TBL in medical education is relatively new, and the evidence for its academic effectiveness is only beginning to grow (Nieder et al. 2005; Letassy et al. 2008; Shellenberger et al. 2009; Koles et al. 2010; Thomas & Bowen 2011).

One of the confounding issues in evaluating the literature to date on TBL is that authors have modified the strategy, sometimes extensively, and do not indicate this in the title. In fact, one must scrutinize the methods to learn exactly what was done, i.e., how were teams created, were the three key components used?

We feel that as medical educators become better at designing TBL modules, ensuring their integration in a course or curriculum, and clarifying what the desired academic

outcomes are, the results will be very positive, especially in contrast to a pure lecture-based curriculum.

We also feel that there are non-academic outcomes that are particularly important for future investigation:

- Does peer evaluation lead to enduring positive changes in how students collaborate?
- How does the decision-making process within a team help students make better decisions independently?
- Since there is emerging evidence for "collective intelligence" within small groups, (Woolley et al. 2010), what characteristics should we use to assign students to teams?
- Does TBL improve clinical reasoning and/or critical thinking skills? If it does, then how can we enhance this outcome?

Why is TBL unique in small group learning?

Small group learning, when done well, as described in the recent AMEE Guide 48 (Edmunds & Brown 2010) provides students with rich opportunities to explore, explain, and understand course material while learning how to communicate, collaborate, and problem-solve as they might in the workplace.

Since PBL is probably the most commonly used small group learning strategy in medical education to date, we consider it relevant to highlight the several differences between PBL and TBL (Table 1).

What additional characteristics make TBL a good fit for healthcare professions education?

These are additional characteristics of TBL that make it unique and particularly well suited for health professions education:

- *Versatility of use.* Large or small classes; single or series of sessions; whole or portions of a course; blends with lectures, labs, other learning activities; inter-professional education activities.
- *Effective team formation.* Teams are created thoughtfully and transparently, and ideally teams stay together for as long as possible.
- *Out-of-class preparation.* The Advance Assignment informs the learner what he/she needs to master before coming to

Table 1. Comparisons between PBL and TBL.

	PBL	TBL
Key principles and assumptions about learning	• Emphasizes student-directed learning and use of knowledge, stimulated by a small group reviewing an authentic, complex clinical case • Learners benefit from learning how to determine what they need to know to best understand the clinical case presented, followed by learning as much as they can	• Emphasizes application of teacher-specified learning goals to solve specifically stated problems posed in one or more authentic, complex clinical cases • Learners benefit most from the opportunity to apply what they learned outside of class to in-class-posed problems through discussions in teams, followed by immediate feedback on their decisions
Basic instructional methods and learning sequence	• Tutors progressively disclose previously prepared cases • Learners analyze disclosed information to identify important facts and surface deficiencies in their knowledge needed to solve a case • Between sessions, learners address knowledge deficiencies and come prepared to apply their new knowledge in tutor-led discussions	• Instructors clearly identify content learners need to learn • Learners come to class prepared to demonstrate their knowledge of this content on RATs, first as individuals and then as teams • Learners apply this knowledge to choose and share solutions to given problems in intra- and inter-team discussions
Incentives which shape learner behavior	• Learners tend to be motivated to participate in group discussions and to study outside of class because of their interest in the case and to contribute their share. An end-of-unit exam may be a motivator. Tutors and peers provide evaluation of participation and contribution	• Learners are motivated to prepare for class – both as individuals and as teams – to do well on RATs. Further motivation to actively participate in the team decision-making comes from the grading of their decisions. An end of course exam is a motivator if the questions are preparatory. Peer evaluation can be an added incentive
Desired outcomes	• Given a complex clinical case, ability to identify what one needs to learn to better understand, reason, think critically. Content mastery. Communicate effectively and work collaboratively in tutor-led small group	• Mastery of content and application of content to solve instructor-defined problems. Think critically, interpret and evaluate data, communicate effectively, work collaboratively in autonomous teams within large class
Role of instructor in the learning process	• Construct cases in such a way that they will stimulate learners to pursue relevant learning issues; facilitate small group discussions; give learners feedback and guidance as needed about their participation, reasoning, mastery of material. Based on observation, grade individuals on their contributions to the group	• Set learning goals; create challenging application questions that stimulate meaningful team discussions; prepareRATs; identify core content and resources; anticipate and address learners' questions and misconceptions.

class in order to be prepared for the RAP and decision-based application assignments that follow.

Immediate feedback

Immediate feedback on both individual and team performance is inherent in the process so that students know "where they are" with respect to understanding both the content and its application. The instructor also has continuous opportunity during the class period to know how learners are thinking about the material as they grapple with using course concepts to solve real-world problems and make medical-practice decisions.

- *Peer evaluation.* Peer evaluation counts and, when the process is properly designed and managed, learners learn how to provide constructive feedback to peers and learn how to adjust their own behaviors to become more effective participants within their teams. This is an increasingly important component of TBL since healthcare professionals are frequently evaluated by their patients, colleagues, administrators, and other members of an allied healthcare team.
- *Authentic problems.* The primary emphasis of the instruction focuses on solving problems, usually based on case vignettes with realistic data and images, that are as authentic as possible, and the choices that the learners have to make force them to partake in the decision-making process that they will regularly encounter in the clinical arena.

Conclusions

TBL is an instructional strategy that is an excellent fit with medical education. It is active learning, learner-centered, holds students accountable for their preparation for class and in-class engagement, and requires them to apply knowledge to solve authentic problems. For any future physician, there are few more important competencies to master than learning how to work collaboratively with others – something that TBL requires. It is a versatile strategy, well suited for large classes (>100 students) or small classes (<25 students), and only needs one instructor.

We have presented how it should be done and caution those who are considering using it to adhere to its structure and process carefully, in order to be successful. We also recommend that interested faculty both attend a real TBL class to learn how students engage with it and attend one or more faculty development workshops about the TBL instructional strategy.

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Suggested further reading

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Michaelsen LK, Sweet M, Parmelee DX. 2008. Team-Based Learning: Small Group Learning's Next Big Step. New Directions for Teaching and Learning. San Francisco, CA: Jossey Bass.

Online resources

Team-based learning collaborative website. Available from: www.teambasedlearning.org.

National Board of Medical Examiners (NBME). Item writing manual. Available from: www.nbme.org/publications/item-writing-manual-download.html

Epstein Educational Enterprises, Immediate Feedback Assessment Technique (IF-AT) form. Available from: www.epsteineducation.com

Glossary of terms

Advance Assignment: Students prepare outside of class for a TBL session by following a specific set of guidelines for reading or other activities. The instructor also provides a set of objectives for this component.

IF-AT™ (*immediate feedback assessment technique*): Answer forms with scratch-offs that indicate a correct answer. Usually used for the tRAT since it provides immediate feedback to a team on whether or not they have the correct answer. If they have selected an incorrect answer, then they may select again until they get it "right," but no longer get full credit. See: www.epsteineducation.com

iRAT (individual readiness assurance test): Upon coming to class for a TBL session, all students answer a set of MCQ that are based on the Advance Assignment. Their grade is recorded and is part of their course grade.

tAPP (team application): The instructor furnishes a case or problem that requires the brain-power of an entire team to answer. This case or problem is *authentic* and solving it requires mastery of content and concepts in the Advance Assignment. All teams work on the same case or problem at the same time and indicate their choices for answers simultaneously.

tRAT (Team Readiness Assurance Test): This is the *same* set of questions that each student has answered individually during the iRAT, but, now the *team* must answer the questions through a consensus-building discussion.