Backward Design

Why "backward" is best

Deliberate and focused instructional design requires us as teachers and curriculum writers to make an important shift in our thinking about the nature of our job. The shift involves thinking a great deal, first, about the specific learnings sought, and the evidence of such learnings, before thinking about what we, as the teacher, will do or provide in teaching and learning activities. Though considerations about what to teach and how to teach it may dominate our thinking as a matter of habit, the challenge is to focus first on the desired learnings from which appropriate teaching will logically follow.

Our lessons, units, and courses should be logically inferred from the results sought, not derived from the methods, books, and activities with which we are most comfortable. Curriculum should lay out the most effective ways of achieving specific results. It is analogous to travel planning. Our frameworks should provide a set of itineraries deliberately designed to meet cultural goals rather than a purposeless tour of all the major sites in a foreign country. In short, the best designs derive backward from the learnings sought.

The appropriateness of this approach becomes clearer when we consider the educational purpose that is the focus of this book: understanding. We cannot say *how* to teach for understanding or *which* material and activities to use until we are quite clear about which specific understandings we are after and what such understandings look like in practice. We can best decide, as guides, what "sites" to have our student "tourists" visit and what specific "culture" they should experience in their brief time there only if we are clear about the particular understandings about the culture we want them to take home. Only by having specified the desired results can we focus on the content, methods, and activities most likely to achieve those results.

But many teachers begin with and remain focused on textbooks, favored lessons, and time-honored activities—the inputs—rather than deriving those means from what is implied in the desired results—the output. To put it in an odd way, too many teachers focus on the *teaching* and not the *learning*. They spend most of their time thinking, first, about what they will do, what materials they will use, and what they will ask students to do rather than first considering what the learner will need in order to accomplish the learning goals.

Consider a typical episode of what might be called *content*-focused design instead of *results*-focused design. The teacher might base a lesson on a particular topic (e.g., racial prejudice), select a resource (e.g., *To Kill a Mockingbird*), choose specific instructional methods based on the resource and topic (e.g., Socratic seminar to discuss the book and cooperative groups to analyze stereotypical images in films and on television), and hope thereby to cause learning (and meet a few English/language arts standards). Finally, the teacher might think up a few essay questions and quizzes for assessing student understanding of the book.

This approach is so common that we may well be tempted to reply, What could be wrong with such an approach? The short answer lies in the basic questions of purpose: Why are we asking students to read this particular novel—in other words, what *learnings* will we seek from their having read it? Do

the students grasp why and how the purpose should influence their studying? What should students be expected to understand and do upon reading the book, related to our goals beyond the book? Unless we begin our design work with a clear insight into larger purposes—whereby the book is properly thought of as a means to an educational end, not an end unto itself—it is unlikely that all students will *understand* the book (and their performance obligations). Without being self-conscious of the specific understandings about prejudice we seek, and how reading and discussing the book will help develop such insights, the goal is far too vague: The approach is more "by hope" than "by design." Such an approach ends up unwittingly being one that could be described like this: Throw some content and activities against the wall and hope some of it sticks.

Answering the "why?" and "so what?" questions that older students always ask (or want to), and doing so in concrete terms as the focus of curriculum planning, is thus the essence of understanding by design. What is difficult for many teachers to see (but easier for students to feel!) is that, without such explicit and transparent priorities, many students find day-to-day work confusing and frustrating.

The twin sins of traditional design

More generally, weak educational design involves two kinds of purposelessness, visible throughout the educational world from kindergarten through graduate school. We call these the "twin sins" of traditional design. The error of activity-oriented design might be called "hands-on without being minds-on"—engaging experiences that lead only accidentally, if at all, to insight or achievement. The activities, though fun and interesting, do not lead anywhere intellectually. Such activity-oriented curricula lack an explicit focus on important ideas and appropriate evidence of learning, especially in the minds of the learners.

A second form of aimlessness goes by the name of "coverage," an approach in which students march through a textbook, page by page (or teachers through lecture notes) in a valiant attempt to traverse all the factual material within a prescribed time. Coverage is thus like a whirlwind tour of Europe, perfectly summarized by the old movie title *If It's Tuesday, This Must Be Belgium*, which properly suggests that no overarching goals inform the tour.

As a broad generalization, the activity focus is more typical at the elementary and lower middle school levels, whereas coverage is a prevalent secondary school and college problem. No guiding intellectual purpose or clear priorities frame the learning experience. In neither case can students see and answer such questions as these: What's the point? What's the big idea here? What does this help us understand or be able to do? To what does this relate? Why should we learn this? Hence, the students try to engage and follow as best they can, hoping that meaning will emerge.

The three stages of backward design

Stage 1: Identify desired results

What should students know, understand, and be able to do? What content is worthy of understanding? What *enduring* understandings are desired? In Stage 1 we consider our goals, examine established content standards (national, state, district), and review curriculum expectations. Because typically we have more content than we can reasonably address within the available time, we must make choices. This first stage in the design process calls for clarity about priorities.

Stage 2: Determine acceptable evidence

How will we know if students have achieved the desired results? What will we accept as evidence of student understanding and proficiency? The backward design orientation suggests that we think about a unit or course in terms of the collected assessment evidence needed to document and validate that the desired learning has been achieved, not simply as content to be covered or as a series of learning activities. This approach encourages teachers and curriculum planners to first "think like an assessor" before designing specific units and lessons, and thus to consider up front how they will determine if students have attained the desired understandings.

Stage 3: Plan learning experiences and instruction

With clearly identified results and appropriate evidence of understanding in mind, it is now the time to fully think through the most appropriate instructional activities. Several key questions must be considered at this stage of backward design: What enabling knowledge (facts, concepts, principles) and skills (processes, procedures, strategies) will students need in order to perform effectively and achieve desired results? What activities will equip students with the needed knowledge and skills? What will need to be taught and coached, and how should it best be taught, in light of performance goals? What materials and resources are best suited to accomplish these goals?

Note that the specifics of instructional planning—choices about teaching methods, sequence of lessons, and resource materials—can be successfully completed only after we identify desired results and assessments and consider what they imply. Teaching is a means to an end. Having a clear goal helps to focus our planning and guide purposeful action toward the intended results.

Conclusion

Backward design may be thought of, in other words, as purposeful task analysis: Given a worthy task to be accomplished, how do we best get everyone equipped? Or we might think of it as building a wise itinerary, using a map: Given a destination, what's the most effective and efficient route? Or we might think of it as planning for coaching: What must learners master if they are to effectively perform? What will count as evidence *on the field*, not merely in drills, that they really get it and are ready to *perform with understanding, knowledge, and skill* on their own? How will the learning be designed so that learners' capacities are developed through use and feedback?

This is all quite logical when you come to understand it, but "backward" from the perspective of much habit and tradition in our field. A major change from common practice occurs as designers must begin to think about assessment *before* deciding what and how they will teach. Rather than creating assessments near the conclusion of a unit of study (or relying on the tests provided by textbook publishers, which may not completely or appropriately assess our standards and goals), backward design calls for us to make our goals or standards specific and concrete, in terms of assessment evidence, as we begin to plan a unit or course.

The rubber meets the road with assessment. Three different teachers may all be working toward the same content standards, but if their assessments vary considerably, how are we to know which students have achieved what? Agreement on needed evidence of learning leads to greater curricular coherence and more reliable evaluation by teachers. Equally important is the long-term gain in teacher, student, and parent insight about what does and does not count as evidence of meeting complex standards.

Introduction to Team-Based Learning

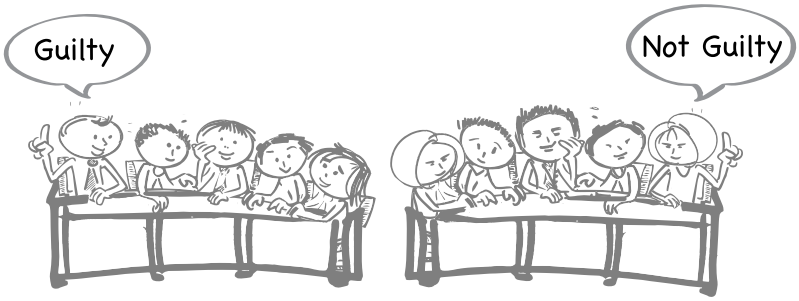
TBL is a uniquely powerful form of small group learning. It provides a complete coherent framework for building a flipped course experience.

TBL lets you achieve two important things:

1. Students come to class prepared by using TBL's ingenious Readiness Assurance Process.
2. Students learn how to apply the course concepts to solve interesting, authentic, real-world problems using TBL's 4 S framework.

It's like a courtroom jury ...

Think of a courtroom jury that sifts through large amounts of evidence, statements, and transcripts to come up with a simple decision: guilty or not guilty. Imagine your work on a jury; you rise to state the jury's verdict, but another person rises from a different jury team in the same courtroom and states a different verdict. You naturally want to talk to them; you naturally want to ask "why?" This simple comparability between decisions, and the natural tendency to ask the question "why" is at the heart of TBL. This "why" motivation provides the instructional fuel to power insightful debates between student teams.

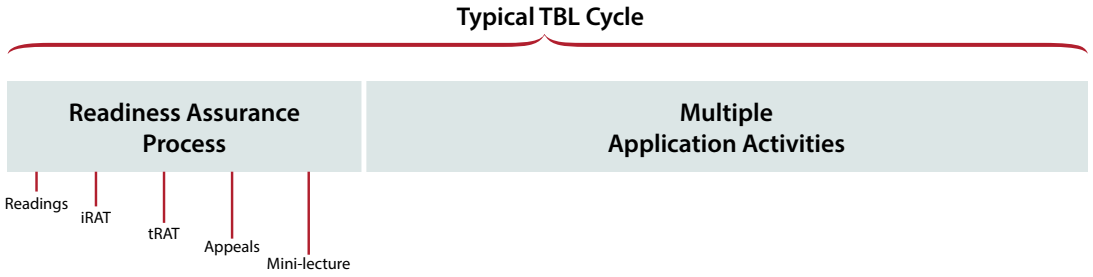


The rhythm of TBL

TBL courses have a recurring pattern of instruction that is typical of many flipped classrooms. Students prepare before class and then students spend the bulk of class time solving problems together. TBL gives you a straightforward whole course framework to design and implement your flipped classroom.

A typical TBL course is divided into five to seven modules. Each module has a similar rhythm, opening with the Readiness Assurance Process that prepares the students for the activities that follow, and then moving to Application Activities that often grow in complexity and length as the module progresses. As the module is ending, you provide some closure and reinforcement. Module length varies in different contexts. In some courses an entire cycle is completed in one long session and in other courses the cycle may be spread across multiple class meetings.

As the next module begins, the familiar TBL rhythm starts to build: out-of-class preparation, the Readiness Assurance Process, followed by Application Activities.



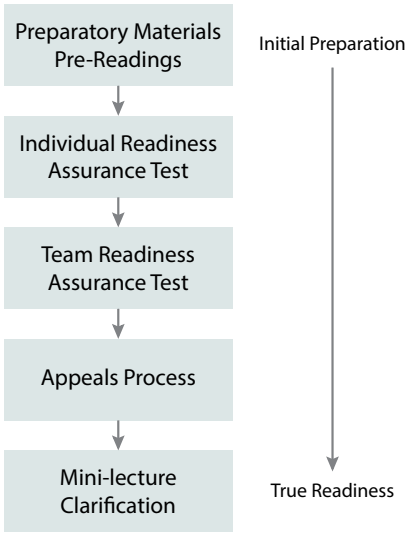
How TBL Works

Readiness Assurance

Getting Your Students Ready

During this 5 stage process at the beginning of each module, students progress from initial preparation to true readiness to begin problem-solving.

Following the Readiness Assurance Process, the bulk of class time is spent with students applying course concepts and solving problems.



1 Pre-Class Preparation

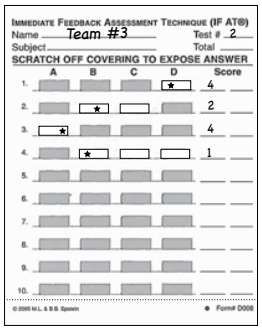
Students are assigned preparatory materials to review before start of each module. The preparatory materials can be textbook chapters, articles, videos, or PowerPoint slides. The preparatory materials should highlight foundational vocabulary and the most important concepts the students need to begin problem solving, but not everything they need to know by module end.

2 Individual Readiness Assurance Test

To begin the classroom portion of the RAP process, students complete a 15-20 multiple-choice question test. They first complete the test individually (iRAT), and then repeat the same exact test with their team (tRAT). The iRAT holds students accountable for acquiring important foundational knowledge from the preparatory materials that will prepare them to begin problem-solving. The questions are typically written at Bloom's levels: remembering, understanding and simple applying.

3 Team Readiness Assurance Test

The Team Readiness Assurance Process Test (tRAT) is the exact same test as the iRAT. A special type of scoring card known as an IF-AT should be used (scratch and win style testing). With IF-AT's, the teams must negotiate which answer to choose, they then scratch off an opaque coating over their answer choice, hoping to find a star that indicates a correct answer. If the team does not discover a star, they continue to discuss the question and sequentially select other choices. The tRATs are high energy learning events.



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4 Appeals

During the closing of the team test, the instructor circulates around the room and encourages teams to consider creating a written appeal for questions they got incorrect. This forces students back into the reading material exactly where they are still having difficulty. The team then researches the "right" answer and may choose to complete the appeals form with their rationale and defense for their alternate answer. The appeal must consist of (a) a clear statement of argument, and (b) evidence cited from the preparation materials. The instructor collects these forms and considers them after class.

5 Mini-lecture

To conclude the Readiness Assurance Process, the instructor focuses a short mini-lecture only on the concepts that are still problematic for the students.

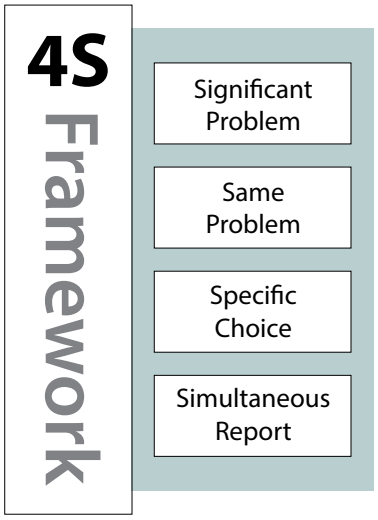
In the words of Bob Philpot at South University, "TBL helps me understand the 10-15% of the course material I really need to talk to the students about."

In Class Activities

4S Problem-Solving Framework

- **Significant Problems**
- **Same Problem**
- **Specific Choice**
- **Simultaneous Report**

In the TBL classroom, the bulk of class time is spent having student teams solve, report, and discuss solutions to relevant, significant problems. Structuring the problems using TBL's 4S Framework lets you leverage the power of team processing without many of the problems that are inherent in other forms of small-group learning. The structure of the TBL activities gives individuals, and teams, many opportunities to make decisions and get timely feedback on the quality of their thinking and their process for arriving at their answer.



1 Significant Problem

Examples of Significant Problem

- A historian reconciles conflicting sources.
- A doctor decides the best course of action.
- A businessperson picks the best location for a business.
- A writer identifies the most powerful passage or best example.

You must use a significant, relevant problem that captures the interest of students. The quality of the problem ultimately controls the effectiveness of an application activity. Problems must require students to use course concepts to solve them.

2 Same Problem

Teams work on the same problem. This ensures the comparability of team solutions and this naturally acts as a potent discussion starter. Having students work on the same problem lets you create reporting opportunities for teams to defend, challenge, discuss, and examine each other's thinking and problem-solving process. Working on the same problem, ensures that students are interested in what other teams decided.

3 Specific Choice

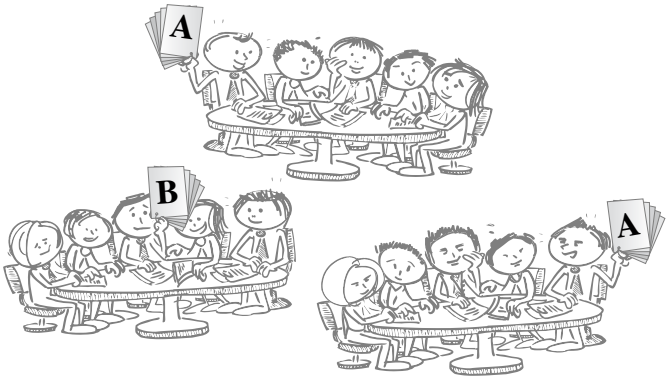
Teams select the best choice from a limited list of options. This ensures that teams can easily compare their final decisions to the decisions of other teams. It is this comparability that drives the rich reporting discussion as teams examine and critique other teams decisions and defend their own.

Examples of Specific Choice

- Which of these is the **best** example of X?
- **Most** important piece of evidence in support of Y?
- Which statement would the author **most** agree with?

4 Simultaneously Report

Simultaneous reporting is most simply accomplished with holding up of a coloured card indicating a particular choice. When a team sees that another team has made a different decision, they naturally want to challenge the other teams' decision. In the ensuing conversation, the teams challenge each other and defend their own thinking. The reporting requires teams to articulate their thinking to other teams – putting their thoughts into words. This helps cognitively with the process of creating enduring, deep understanding. The feedback from their peers is immediate and focused on "how did you arrive at your decision" and not "which is the right answer."



4 Essential Elements of TBL

Teams must be properly formed and managed

TBL works best with large, diverse teams. TBL teams should have 5-7 students. Teams should be created by instructor and uniformly distribute the student assets you feel are important for team success. Teams need to be permanent so team cohesion has time to build.

Getting Students Ready

The magic of the Readiness Assurance Process is that it builds on the initial preparation, changing it into true readiness to begin problem-solving. At the simplest level, the RAP is a series of multiple-choice tests. First the test is taken individually, and then the same test is immediately retaken in teams.

For more information on how to get started.

Visit
www.teambasedlearning.org

Classroom materials, books, videos, workshop schedules and more!

Applying course concepts

Use the 4 S problem-solving framework to have students make complex decisions and then get rich, immediate, and specific feedback on the quality of their decisions. The give-and-take discussions that follows after teams publically report their decisions is a powerful opportunity deepen students understanding.

Making students accountable

Making students truly accountable is key. There is individual accountability from the iRAT, but what is most motivating is the accountability to teammates during the tRAT's and Application Activities. Peer evaluation is key to giving the grading scheme enough teeth to motivate students.

Teachers Say It Works!

The enthusiasm and energy of students. It's just so much fun!

Larry Michaelsen
University of Central Missouri

Students excited about learning and faculty falling in love with teaching. The way learning should be.

Holly Bender
Iowa State University

Students are so engaged in conversation with each other and the task that, literally, they don't know I am there. My favorite days are when I have to tell them to leave.

Laura Madson
New Mexico State University

I think the genius of TBL is that it maximizes the advantages of group learning while minimizing the disadvantages.

Brent Maclaine
University of Prince Edward Island

The Literature Says It Works!

Students are more engaged

Students reported higher level of engagement in TBL courses (Chung et al., 2009; Clark et al., 2008; Kelly et al., 2005; Levine et al., 2004).

Increased excitement in the TBL classroom

Teachers report increased excitement and engagement in their classrooms (Andersen et al., 2011; Dana, 2007; Jacobson, 2011; Letassy et al.; 2008; Nicoll-Senft, 2009).

Teams outperform best members

The worst team typically outperforms the best student. In 20 years of results Michaelsen (1989) found that 99.95% of teams outperformed their best member by an average of 14%.

Students perform better on final and standardized exams

TBL students outperform non-TBL students on examinations (Grady, 2011; Letassy et al., 2008; Persky, 2012, Zingone et al.; 2011, Koles et al., 2005; Koles et al., 2010; Thomas & Bowen, 2011).

A large class can be an asset

Michaelsen, Knight, Fink (2002) found that students actually perceived a larger class size as beneficial to their learning with TBL.

1

TBL is a collection of practices that support one another for powerful instructional effect. This chapter describes the building blocks of team-based learning and the steps necessary to put them into place.

The Essential Elements of Team-Based Learning

Larry K. Michaelsen, Michael Sweet

Team-based learning (TBL) possibly relies on small group interaction more heavily than any other commonly used instructional strategy in postsecondary education (for comparative discussion of different approaches, see Fink, 2004; Johnson, Johnson, and Smith, 2007; Millis and Cottell, 1998). This conclusion is based on three facts. First, with TBL, group work is central to exposing students to and improving their ability to apply course content. Second, with TBL, the vast majority of class time is used for group work. Third, courses taught with TBL typically involve multiple group assignments that are designed to improve learning and promote the development of self-managed learning teams.

This chapter begins with a brief overview of TBL. Next, we discuss the four essential elements of TBL and then walk through the steps required to implement them. Finally, we examine some of the benefits that students, administrators, and faculty can expect from a successful implementation of TBL.

A Broad Overview of TBL

The primary learning objective in TBL is to go beyond simply covering content and focus on ensuring that students have the opportunity to practice using course concepts to solve problems. Thus, TBL is designed to provide students with both conceptual and procedural knowledge. Although some time in the TBL classroom is spent ensuring that students master the course

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content, the vast majority of class time is used for team assignments that focus on using course content to solve the kinds of problems that students are likely to face in the future. Figure 1.1 outlines generally how time in one unit of a TBL course is organized.

In a TBL course, students are strategically organized into permanent groups for the term, and the course content is organized into major units—typically five to seven. Before any in-class content work, students must study assigned materials because each unit begins with the readiness assurance process (RAP). The RAP consists of a short test on the key ideas from the readings that students complete as individuals; then they take the same test again as a team, coming to consensus on team answers. Students receive immediate feedback on the team test and then have the opportunity to write evidence-based appeals if they feel they can make valid arguments for their answer to questions that they got wrong. The final step in the RAP is a lecture (usually very short and always very specific) to enable the instructor to clarify any misperceptions that become apparent during the team test and the appeals.

Once the RAP is completed, the remainder (and the majority) of the learning unit is spent on in-class activities and assignments that require students to practice using the course content.

The Four Essential Elements of Team-Based Learning

Shifting from simply familiarizing students with course concepts to requiring that students use those concepts to solve problems is no small task. Making this shift requires changes in the roles of both instructor and students. The instructor's primary role shifts from dispensing information to designing and managing the overall instructional process, and the students' role shifts from being passive recipients of information to one of accepting responsibility for the initial exposure to the course content so that they will be prepared for the in-class teamwork.

Changes of this magnitude do not happen automatically and may even seem to be a dream rather than an achievable reality. They are, however, achievable when the four essential elements of TBL are successfully implemented:

- Groups. Groups must be properly formed and managed.
- Accountability. Students must be accountable for the quality of their individual and group work.
- Feedback. Students must receive frequent and timely feedback.
- Assignment design. Group assignments must promote both learning and team development.

When these four elements are implemented in a course, the stage is set for student groups to evolve into cohesive learning teams.

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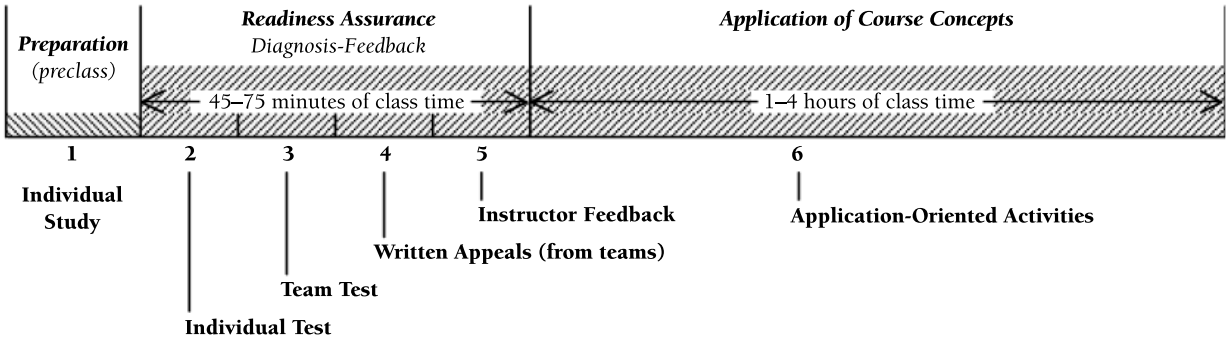
Figure 1.1. Team-Based Instructional Activity Sequence



Note: This sequence is repeated for each major instructional unit—typically five to seven per course.

Element 1: Properly Formed and Managed Groups. TBL requires that the instructor oversee the formation of the groups so that he or she can manage three important variables: ensuring that the groups have adequate resources to draw from in completing their assignments and approximately the same level of those resources across groups, avoiding membership coalitions that are likely to interfere with the development of group cohesiveness, and ensuring that groups have the opportunity to develop into learning teams.

Distributing Member Resources. In order for groups to function as effectively as possible, they should be as diverse as possible. Each group should contain a mix of student characteristics that might make the course easier or more difficult for a student to do well in the course (for example, previous course work or course-related practical experience) as well as demographic characteristics like gender and ethnicity. The goal here is to equip groups to succeed by populating them with members who will bring different perspectives to the task.

Findings in both group dynamics research (Brobeck and others, 2002) and educational research (Chan, Burtis, and Bereiter, 1997) illuminate the positive impact of diverse input in problem-solving discussions on both learning and performance. When group members bring many different perspectives to a task, their process of collaborative knowledge building in pursuit of consensus is powerful to watch. In addition, although member diversity initially inhibits both group processes and performance, it is likely to become an asset when members have worked together over time and under conditions that promote group cohesiveness (Watson, Kumar, and Michaelsen, 1993).

Minimizing Barriers to Group Cohesiveness: Avoiding Coalitions. Coalitions within a group are likely to threaten its overall development. In newly formed groups, either a previously established relationship between a subset of members in the group (such as a boyfriend and girlfriend or fraternity brothers) or the potential for a cohesive subgroup based on background factors such as nationality, culture, or native language is likely to burden a group with insider-outsider tension that can plague the group throughout the term. Because it is human nature to seek out similar others, allowing students free rein in forming their own groups practically ensures the existence of potentially disruptive subgroups (Fiechtner and Davis, 1985; Michaelsen and Black, 1994).

Time. Any group dynamics textbook will tell you that groups need time to develop into high-performing teams, regardless of whether you favor sequential or life cycle models (Tuckman, 1965; Tuckman and Jensen, 1977), cyclical models (Worchel, Wood, and Simpson, 1992), or adaptive or nonsequential models (McGrath, 1991). For this reason, students should stay in the same group for the entire course. Although even a single well-designed group assignment usually produces a variety of positive outcomes, only when students work together over time can their groups become cohesive enough to evolve into self-managed and truly effective learning teams.

Element 2: Student Accountability for Individual and Group Work. In lecture classes, there is no need for students to be accountable to anyone other than the instructor. By contrast, TBL requires students to be accountable to both the instructor and their teammates for the quality and quantity of their individual work. Furthermore, teams must accountable for the quality and quantity of their work as a unit. (For a review of the effects of accountability on an array of social judgments and choices, see Lerner and Tetlock, 1999.)

Accountability for Individual Preclass Preparation. Lack of preparation places clear limits on both individual learning and team development. If several members of a team come unprepared to contribute to a complex group task, then the team as a whole is far less likely to succeed at that task, cheating its members of the learning that the task was designed to stimulate. No amount of discussion can overcome absolute ignorance. Furthermore, lack of preparation also hinders the development of cohesiveness because those who do make the effort to be prepared will resent having to carry their peers. As a result, the effective use of learning groups clearly requires that individual students be made accountable for class preparation.

Accountability for Contributing to The Team. The next step is ensuring that members contribute time and effort to group work. In order to accurately assess members' contributions to the success of their teams, it is imperative that instructors involve the students themselves in a peer assessment process. That is, members should be given the opportunity to evaluate one another's contributions to the activities of the team. Contributions to the team include activities such as individual preparation for teamwork, reliable class attendance, attendance at team meetings that may have occurred outside class, positive contributions to team discussions, and valuing and encouraging contributions from fellow team members. Peer assessment is essential because team members are typically the only ones who have enough information to evaluate one another's contributions accurately.

Accountability for High-Quality Team Performance. The third significant factor in ensuring accountability is developing an effective means to assess team performance. There are two keys to effectively assessing teams. One is using assignments that require teams to create a product that can be readily compared across teams and with "expert" opinions, and the other is using procedures to ensure that such comparisons occur frequently and in a timely manner.

Element 3: Frequent Immediate Student Feedback. Immediate feedback is the primary instructional lever in TBL for two very different reasons. First, feedback is essential to content learning and retention—a notion that not only makes intuitive sense but is also well documented in educational research literature (Bruning, Schraw, and Ronning, 1994; Kulik and Kulik, 1988; Hattie and Timperley, 2007). Second, immediate feedback has tremendous impact on group development (for a review, see Birmingham and McCord, 2004).

Element 4: Assignments That Promote Both Learning and Team Development. The most fundamental aspect of designing team assignments that promote both learning and team development is ensuring that they truly require group interaction. In most cases, team assignments generate a high level of interaction if they require teams to use course concepts to make decisions that involve a complex set of issues and enable teams to report their decisions in a simple form. When assignments emphasize making decisions, most students choose to complete the task by engaging each other in a give-and-take content-related discussion. By contrast, assignments that involve producing complex output such as a lengthy document often limit both learning and team development because they typically inhibit intrateam discussions in two ways. First, discussions are likely to be much shorter because students are likely to feel an urgency to create the product that is to be graded. Second, instead of focusing on content-related issues, they are likely to center on how to divide up the work. Thus, complex product outputs such as a lengthy document seldom contribute to team development because they are likely to have been created by individual members working alone on their part of the overall project.

Summary. By adhering to the four essential elements of TBL—careful design of groups, accountability, feedback, and assignments—teachers create a context that promotes the quantity and quality of interaction required to transform groups into highly effective learning teams. Appropriately forming the teams puts them on equal footing and greatly reduces the possibility of mistrust from preexisting relationships between a subset of team members. Holding students accountable for preparation and attendance motivates team members to behave in prosocial ways that build cohesiveness and foster trust. Using RAPs and other assignments to provide ongoing and timely feedback on both individual and team performance enables teams to develop confidence in their ability to capture the intellectual resources of all their members. Assignments that promote both learning and team development motivate members to challenge others' ideas for the good of the team. Also, over time, students' confidence in their teams grows to the point that they are willing and able to tackle difficult assignments with little or no external help.

Implementing Team-Based Learning

Effectively using TBL typically requires redesigning a course from beginning to end, and the redesign process should begin well before the start of the school term. The process involves making decisions about and designing activities at four different times: before class begins, the first day of class, each major unit of instruction, and near the end of the course. In this section, we discuss the practical steps a TBL instructor takes at each of these points, but for a treatment that is even detailed and practical, we direct readers to Michaelsen, Knight, and Fink (2004).

Before Class Begins. Traditional education, particularly in undergraduate programs, has tended to separate knowledge acquisition from knowledge application both between and within courses. In a typical biology course, for example, students listen to lectures through which they are expected to absorb a great deal of knowledge that they will then later be asked to put to use in a biology lab. In fact, even within higher-level courses, students often spend much of the term absorbing knowledge that they do not put to use until a project that is due just prior to the final exam.

TBL uses a fundamentally different knowledge acquisition and knowledge application model. With TBL, students repeat the knowledge acquisition and knowledge application cycle several times within each individual course. They individually study the course content, discuss it with their peers and the instructor, and immediately apply it in making choices that require them to use their knowledge. Thus, students in TBL courses develop a much better sense of the relevance of the material because they seldom have to make unreasonably large inferences about when and how the content might become useful in the real world. Rather than being filled with libraries of "inert knowledge" (Whitehead, 1929), from which they then later must extract needed information with great effort, students walk away from TBL courses having already begun the practical problem-solving process of learning to use their knowledge in context.

This benefit, however, does not occur by accident. Designing a successful TBL course involves making decisions related to first identifying and clustering instructional objectives and then designing a grading system around them.

Identifying Instructional Objectives. Designing a TBL course requires instructors to "think backward." What is meant by "think backward"? In most forms of higher education, teachers design their courses by asking themselves what they feel students need to know, then telling the students that information, and finally testing the students on how well they absorbed what they were told. In contrast, designing a TBL course requires instructors to "think backward"—backward because they are planned around what they want students to be able to do when they have finished the course; only then do instructors think about what students need to know. Wiggins and McTighe (1998) used the term *backward design* to describe this method of course design, which enables the instructor to build a course that provides students both declarative and procedural knowledge (in other words, conceptual knowledge and the ability to use that knowledge in decision making). This is a useful distinction, but if you have taught only with conceptual familiarization as your goal, it can be surprisingly difficult to identify what exactly you want students to be able to do on completion of a course. The following question is a good a good place to start.

What are the students who really understand the material doing that shows you they get it? Imagine you are working shoulder-to-shoulder with a former student who is now a junior colleague. In a wonderful moment,

you see that colleague do something that makes you think, "Hey! She really got from my class what I wanted her to get. There's the evidence right there!" When you are designing a course backward, the question you ask yourself is: "What specifically is that evidence? What could a former student be doing in a moment like that to make it obvious she really internalized what you were trying to teach her and is putting it to use in a meaningful way?"

For every course, there are several answers to this question, and these different answers correspond to the units of the redesigned version of the course. A given real-world moment will likely demand knowledge from one part of a course but not another, so for any given course, you should brainstorm about a half-dozen of these proud moments in which a former student is making it obvious that she really learned what you wanted her to. For now, do not think about the classroom; just imagine she is doing something in an actual organizational context. Also, do not be afraid to get too detailed as you visualize these moments. In fact, come up with as many details as you can about how this former student is doing what she is doing, what decisions she is making, in what sequence, under what conditions, and so on.

These detailed scenarios become useful in three ways. First, the actions taking place in the scenarios will help you organize your course into units. Second, the scenarios will enable you to use class time to build students' applied knowledge instead of inert knowledge. Third, the details of the scenario will help you design the criteria for the assessments on which you can base students' grades.

Once you have brainstormed the scenarios and the details that accompany them, you have identified your instructional objectives, which often involve making decisions that are based on insightful applications of the concepts from your course. Now you are ready to ask three more questions:

- *What will students need to know in order to be able to do those things?* Answers to this question will guide your selection of a textbook, the contents of your course packet, experiential exercises, and are likely to prompt you to provide supplementary materials of your own creation or simple reading guides to help students focus on what you consider most important in the readings or lab findings. In addition, the answers will be key in developing questions for the readiness assurance process.
- *While solving problems, what knowledge will students need to make decisions?* Answers to this question will help you import the use of course knowledge from your brainstormed real-world scenarios into the classroom. You may not be able to bring the actual organizational settings in which your scenarios occurred into the classroom, although computer simulations, video (including full-length feature films), and requiring students to learn by doing (see Miller, 1991, and Michaelsen and McCord, 2006) are coming much closer to approaching the real world. But you can provide enough relevant information about those settings to design

activities that require students to face the same kinds of problems and make the same kinds of decisions they will make in clinical and laboratory settings.

- *What criteria separate a well-made decision from a poorly made decision using this knowledge?* Answers to this question will help you begin building the measures you will use to determine how well the students have learned the material and how well they can put it to use under specific conditions.

In summary, TBL leverages the power of action-based instructional objectives to not only expose students to course content but also give them practice using it. When you are determining an instructional objective, it is crucial to know how to assess the extent to which students have mastered that objective. Some teachers feel that designing assessments first removes something from the value of instruction—that it simply becomes teaching to the test. With TBL the view is that you should teach to the test as long as the test represents (as closely as possible) the real use to which students will ultimately apply the course material: what they are going to do with it, not just what they should know about it.

Designing a Grading System. The other step in redesigning the course is to ensure that the grading system is designed to reward the right things. An effective grading system for TBL must provide incentives for individual contributions and effective work by the teams, as well as address the equity concerns that naturally arise when group work is part of an individual's grade. The primary concern here is typically borne from past group work situations in which students were saddled with free-riding team members and have resented it ever since. Students worry that they will be forced to choose between getting a low grade or carrying their less able or less motivated peers. Instructors worry that they will have to choose between grading rigorously and grading fairly.

Fortunately, many of these concerns are alleviated by a grading system in which a significant proportion of the grade is based on individual performance, team performance, and each member's contributions to the success of the teams. As long as that standard is met, the primary remaining concern is that the relative weight of the factors is acceptable to both the instructor and the students.

The First Day of Class. Activities that occur during the first few hours of class are critical to the success of TBL. During that time, the teacher must accomplish four objectives: ensure that students understand why you (the instructor) have decided to use TBL and what that means about the way the class will be conducted, form the groups, alleviate students' concerns about the grading system, and set up mechanisms to encourage the development of positive group norms.

Introducing Students to TBL. Because the roles of instructor and students are so fundamentally different from traditional instructional practice, it is critical that students understand both the rationale for using TBL and

what that means about the way the class will be conducted. Educating students about TBL requires at a minimum providing them with an overview of the basic features of TBL, how TBL affects the role of the instructor and their role as students, and why they are likely to benefit from their experience in the course. This information should be printed in the course syllabus, presented orally, and demonstrated by one or more activities.

In order to foster students' understanding of TBL, we recommend two activities. The first is to explain the basic features of TBL using overhead transparencies (or a PowerPoint presentation) and clearly spelling out how the learning objectives for the course will be accomplished through the use of TBL, compared to how the same objectives would be achieved using a lecture-discussion course format. The second activity is a demonstration of a readiness assurance process using the course syllabus, a short reading on TBL, or some potentially useful ideas, such as what helps and hinders team development or strategies for giving helpful feedback (see Michaelsen and Schultheiss, 1988) as the content material to be covered. (In a class period of less than an hour, this activity might occur on day 2.)

Forming the Groups. When forming groups, you must consider the course-relevant characteristics of the students and the potential for the emergence of subgroups. As a result, the starting point in the group formation process is to gather information about specific student characteristics that will make it easier or more difficult for a student to succeed in the class. For a particular course, characteristics that could make it easier for a student to succeed might include previous relevant course work or practical experience or access to perspectives from other cultures. Most commonly, characteristics making it more difficult for students to succeed are the absence of those that would make it easier, but might include such things as a lack of language fluency.

We recommend forming the groups in class in the presence of the students to eliminate student concerns about ulterior motives the instructor may have had in forming groups. (For a depiction of how to form groups quickly and effectively, see Michaelsen and Sweet, 2008, and for a more detailed explanation and video demonstration, go to www.teambasedlearning.org.)

Alleviating Student Concerns About Grades. The next step in getting started on the right foot with TBL is to address student concerns about the grading system. Fortunately, student anxiety based on previous experience with divided-up group assignments largely evaporates as students come to understand two of the essential features of TBL. One is that two elements of the grading system create a high level of individual accountability for preclass preparation, class attendance, and devoting time and energy to group assignments: counting individual scores on the readiness assurance tests and basing part of the grade on a peer evaluation. The other reassuring feature is that team assignments will be done in class and will be based on thinking, discussing, and deciding, so it is highly unlikely that one or two less-motivated teammates members can put the entire group at risk.

Many instructors choose to alleviate student concerns about grades by directly involving students in customizing the grading system to the class. Students become involved by participating in setting grade weights (Michaelsen, Cragin, and Watson, 1981; Michaelsen, Knight, and Fink, 2004). Within limits set by the instructor, representatives of the newly formed teams negotiate with one another to reach a consensus (all of the representatives must agree) on a mutually acceptable set of weights for each of the grade components: individual performance, team performance, and each member's contributions to the success of the team. After an agreement has been reached regarding the grade weight for each component, the standard applies for all groups for the remainder of the course.

Each Major Unit of Instruction. Each unit of a TBL course begins with a readiness assurance process (RAP), which occurs at least five to seven times each term. The RAP provides the foundation for individual and team accountability and has five major components: (1) assigned readings, (2) individual tests, (3) team tests, (4) an appeals process, and (5) instructor feedback.

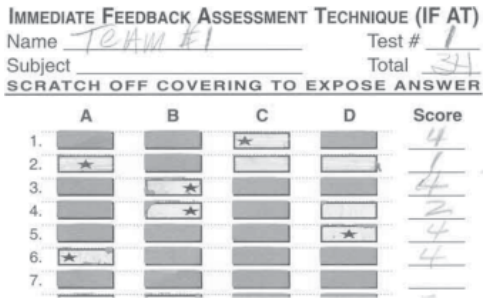
Assigned Readings. Prior to the beginning of each major instructional unit, students are given reading and other assignments that should contain information on the concepts and ideas that must be understood to be able to solve the problem set out for this unit. Students complete the assignments and come to the next class period prepared to take a test on the assigned materials.

Individual Test. The first in-class activity in each instructional unit is an individual readiness assurance test (iRAT) over the material contained in the preclass assignments. The tests typically consist of multiple-choice questions that enable the instructor to assess whether students have a sound understanding of the key concepts from the readings. As a result, the questions should focus on foundational concepts, not picky details, and be difficult enough to stimulate team discussion.

Team Test. When students have finished the iRAT, they turn in their answers (which are often scored during the team test) and immediately proceed to the third phase of the readiness assurance process, the tRAT. During this third phase, students retake the same test, but this time as a team, and the teams must reach agreement on the answers to each test question. They then immediately check the correctness of their decision using the intermediate feedback assessment technique (IF-AT), a self-scoring answer sheet (see Figure 1.2) that provides feedback on each team decision. With the IF-AT answer sheets, students scratch off the covering of one of four (or five) boxes in search of a mark indicating they have found the correct answer. If they find the mark on the first try, they receive full credit. If not, they continue scratching until they find the mark, but their score is reduced with each unsuccessful scratch. This allows teams to receive partial credit for proximate knowledge.

The answer sheets are an effective way to provide timely feedback on the team RATs (not the iRATs—otherwise members would know the answers before the team test and discussion would be pointless). Furthermore, using

Figure 1.2. Immediate Feedback Assessment Technique



the answer sheets makes it possible to provide real-time content feedback to multiple teams without requiring them to maintain the same work pace.

Getting real-time feedback from the IF-AT provides two key benefits to the teams. First, it enables members to correct their misconceptions of the subject matter. Finding a star immediately after scratching the choice confirms the validity of it, and finding a blank box lets them know they have more work to do. Second, it promotes both the ability and the motivation for teams, with no input from the instructor, to learn how to work together effectively. In fact, those who have used the IF-ATs for their tRATs have learned that doing so virtually eliminates any possibility that one or two members might dominate team discussions. "Pushy" members are only one scratch away from embarrassing themselves, and quiet members are one scratch away from being validated as a valuable source of information and two scratches away from being told that they need to speak up.

The impact of the IF-AT on team development is immediate, powerful, and extremely positive. In our judgment, using the IF-ATs with the tRATs is the most effective tool available for promoting both concept understanding and cohesiveness in learning teams. Anyone who does not use them will miss a sure-fire way to implement TBL successfully.

Appeals Process. At this point in the readiness assurance process, students proceed to the fourth phase, which gives them the opportunity to refer to their assigned reading material and appeal any questions missed on the group test. That is, students are allowed to do a focused restudy of the assigned readings (this phase is "open book") to challenge the teacher about their responses on specific items on the team test or about confusion created by either the quality of the questions or inadequacies of the preclass readings.

Discussion among group members is usually very animated while the students work together to build a case to support their appeals. The students must produce compelling evidence to convince the teacher to award credit for the answers they missed. Teachers listening to students argue the fine details

of course material while writing team appeals report being convinced their students learn more from appealing answers they got wrong than from confirming the answers they got right. As an integral part of the readiness assurance process, this appeals exercise provides yet another review of the readings.

Instructor Feedback. The fifth and final part of the readiness assurance process is oral feedback from the instructor. This feedback comes immediately after the appeals process and allows the instructor to clear up any confusion students may have about any of the concepts presented in the readings. As a result, input from the instructor is typically limited to a brief, focused review of only the most challenging aspects of the preclass reading assignment.

The Readiness Assurance Process in Summary. This process allows instructors to minimize class time that often is used instead to cover material that students can learn on their own. Time is saved because the instructor's input occurs after students have individually studied the material, taken an individual test focused on key concepts from the reading assignment, retaken the same test as a member of a learning team, and completed a focused restudy of the most difficult concepts. A cursory review of team test results illuminates for instructors which concepts need additional attention so that they can correct students' misunderstandings. In contrast to the concerns many instructors express about "losing time to group work" and not being able to cover as much content, many others report being able to cover more with the readiness assurance process than they can through lectures (Knight, 2004). Leveraging the motivational power and instructional efficiency of the readiness assurance process leaves the class a great deal of class time to develop students' higher-level learning skills as they tackle multiple and challenging application-oriented assignments.

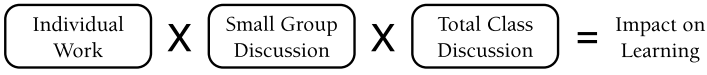
Beyond its instructional power, the readiness assurance process is the backbone of TBL because it promotes team development in four specific ways. First, starting early in the course (usually the first few class hours), students are exposed to immediate and unambiguous feedback on both individual and team performance. As a result, each member is explicitly accountable for his or her preclass preparation. Second, because team members work face-to-face, the impact of the interaction is immediate and personal. Third, students have a strong vested interest in the outcome of the group and are motivated to engage in a high level of interaction. Finally, cohesiveness continues to build during the final stage of the process when the instructor is presenting information. This is because unlike lectures, the content of the instructor's comments is determined by students' choices and actions during the readiness tests. Thus, the instructor's comments provide either positive reinforcement (they celebrate together) or corrective instruction (which, particularly in the presence of other groups, can be experienced as embarrassing and, in this way, provide an "external threat" that builds cohesiveness within a group). Although the impact of the readiness assurance process on student learning is limited primarily to ensuring that they have a solid exposure to the content, it also increases students' ability to

solve difficult problems for two reasons. First, by encouraging preclass preparation and a lively discussion, the process builds the intellectual competence of team members. Second, because they have immediate performance feedback, the experience of working together during the group and in preparing appeals heightens their ability and willingness to provide high-quality content feedback to one another. As a result, the readiness assurance process provides a practical way of ensuring that even in large classes, students are exposed to a high volume of immediate feedback that in some ways can actually be better than having a one-on-one relationship between student and instructor.

Promoting Higher-Level Learning. The final stage in the TBL instructional activity sequence for each unit of instruction is using one or more assignments that provide students with the opportunity to deepen their understanding by having groups use the concepts to solve a problem. These application assignments must foster both accountability and give-and-take discussion first within and then between groups. Designing these assignments is probably the most challenging aspect of implementing TBL.

The key to creating and implementing effective group assignments is following what TBL users fondly refer to as the 4 S's: (1) assignments should always be designed around a problem that is *significant to students,* (2) all of the students in the class should be working on the *same* problem, (3) students should be required to make a *specific* choice, and (4) groups should *simultaneously* report their choices (Figure 1.3). Furthermore, these procedures apply to all three stages in which students interface with course concepts—individual work prior to group discussions, discussions within groups, and whole-class discussion between groups. The 4 S's are explained in the following paragraphs.

Figure 1.3. Keys to Creating Effective Group Assignments



To obtain the maximum impact on learning, assignments at each stage should be characterized by 4 S's:

- **Significant –** Individuals and groups should work on a problem, case, or question demonstrating concept's usefulness.
- **Same problem –** Individuals and groups should work on the same problem, case, or question.
- **Specific choice –** Individuals and groups should be required to use course concepts to make a specific choice.
- **Simultaneously report –** If possible, individuals and groups should report their choices simultaneously.

- *Significant problem.* Effective assignments must capture students' interest. Unless assignments are built around what they see as a relevant issue, most students will view what they are being asked to do as busywork and will put forth the minimum effort required to get a satisfactory grade. The key to identifying what will be significant to students is using backward design. If you identify something you want students to be able to do and give them the chance to try, it is likely that your enthusiasm will carry over to your students in a way that rarely happens when you organize your teaching around what you think students should know.
- *Same problem.* Group assignments are effective only to the extent that they promote discussion both within and between groups. Assigning students to work on different problems practically eliminates meaningful discussions because students have little energy to engage in a comparison of apples and oranges, and students will not be exposed to feedback on the quality of their thinking as either individuals or teams. In order to facilitate a conceptually rich and energetic exchange, students must have a common frame of reference that is possible only when they are working on the same problem, that is, the same assignment or learning activity.
- *Specific choice.* Cognitive research shows that learning is greatly enhanced when students are required to engage in higher-level thinking (Mayer, 2002; Pintrich, 2002; Scandura, 1983). In order to challenge students to process information at higher levels of cognitive complexity, an educational adage (sometimes attributed to William Sparke) is that teaching consists of causing people to go into situations from which they cannot escape except by thinking.

In general, the best activity to accomplish this goal is to require students to make a specific choice. Think of the task of a courtroom jury: members are given complex information and asked to produce a simple decision: guilty or not guilty. As a result, nearly one hundred percent of their time and effort is spent digging into the details of their content. In the classroom, the best way to promote content-related discussion is to use assignments that require groups to use course concepts to make decisions on questions such as these:

- Which line on this tax form would pose the greatest financial risk due to an IRS audit? Why?
- Given a set of real data, which of the following advertising claims is least (or most) supportable? Why?
- What is the most dangerous aspect of this bridge design? Why?
- Given four short paragraphs, which is the best (or worst) example of an enthymeme? Why?

For a much more thorough discussion of assignments and a rationale as to why they work so well in promoting both student learning and team development, see Michaelsen, Knight, and Fink, 2004).

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- *Simultaneous reports.* Once groups have made their choices, they can share the result of their thinking with the rest of the class sequentially or simultaneously. The problem with sequential reporting is that the initial response often has a powerful impact on the subsequent discussion because later-reporting teams tend to change their answer in response to what seems to be an emerging majority view—even if that majority is wrong.

This phenomenon, which we call answer drift, limits both learning and team development for a variety of reasons. One is that it is most likely to occur when the problems being discussed have the greatest potential for producing a meaningful discussion. That is because the more difficult or ambiguous the problem is, the greater the likelihood is that the initial response would be incomplete or even incorrect, and subsequent groups would be unsure about the correctness of their answer. Another is that answer drift discourages give-and-take discussions because later responders deliberately downplay differences between their initial answer and the one that is being discussed. Finally, sequential reporting limits accountability because the only group that is truly accountable is the one that opens the discussion.

Requiring groups to simultaneously reveal their answers virtually eliminates the main problems that result from sequential reporting. Consider the question in a tax accounting course on an assignment requiring teams to choose a specific line on a tax form that would pose the greatest financial risk due to an IRS audit. One option would be for the instructor to signal the teams to simultaneously hold up a card with the line number corresponding to their choice (others simultaneous report options are discussed in Sweet, Wright, and Michaelsen, 2008). Requiring a simultaneous public commitment to a specific choice increases both learning and team development because each team is accountable for its choice and motivated to defend its position. Moreover, the more difficult the problem, the greater the potential is for disagreements that are likely to prompt give-and-take discussion, and the teams become more cohesive as they pull together in an attempt to defend their position.

Near the End of the Course. Although TBL provides students with multiple opportunities for learning along the way, instructors can solidify and extend student understanding of both course content and group process issues by reminding students to reflect on what the TBL experience has taught them about course concepts, the value of teams, the kinds of interaction that promote effective teamwork, themselves, and how certain aspects of the course have encouraged positive group norms.

Reinforcing Content Learning. One of the greatest benefits of using TBL is also a potential danger. Since so little class time is aimed at providing students with their initial exposure to course concepts, many fail to realize how much they have learned. In part, this seems to result from the fact that with TBL, the volume of their lecture notes is far less than in typical courses. As a result, some students are a bit uneasy—even if they are aware that the

scores from TBL sections on common midterm exams were significantly higher than scores from non-TBL sections. As a result, on an ongoing basis—and especially near the end of the course—instructors should make explicit connections between end-of-course exams and the RAT questions and application assignments. In addition, an effective way to reassure students is devoting a class period to a concept review. In its simplest form, this involves (1) giving students an extensive list of the key concepts from the course, (2) asking them to individually identify any concepts that they do not recognize, (3) compare their conclusions in the teams, and (4) review any concepts that teams identify as needing additional attention.

Learning About the Value of Teams. Concerns about better students being burdened by less motivated or less able peers are commonplace with other group-based instructional approaches. TBL, however, enables instructors to provide students with compelling empirical evidence of the value of teams for tackling difficult intellectual challenges. For example, in taking both individual and team tests, students generally have the impression that the teams are outperforming their own best member, but are seldom aware of either the magnitude or the pervasiveness of the effect. Near the end of each term, we create a transparency that shows cumulative scores from the tests for each team—the low, average, and high member score; the team score; and the difference between the highest member score and the team score (see Michaelsen, Knight, and Fink, 2004). Most students are stunned when they see the pattern of scores for the entire class. In the past twenty years, over 99.9 percent of the nearly sixteen hundred teams in our classes have outperformed their own best member by an average of nearly 11 percent. In fact, in the majority of classes, the lowest team score in the class is higher than the single best individual score in the entire class (Michaelsen, Watson, and Black, 1989).

Recognizing Effective Team Interaction. Over time, teams get increasingly better at ferreting out and using members' intellectual resources in making decisions (Watson, Michaelsen, and Sharp, 1991). However, unless instructors use an activity that prompts members to explicitly think about group process issues, they are likely to miss an important teaching opportunity. This is because most students, although pleased about the results, generally fail to recognize the changes in members' behavior that have made the improvements possible.

We have used two approaches for increasing students' awareness of the relationship between group processes and group effectiveness. The aim of both approaches is to have students reflect on how and why members' interaction patterns have changed as their team became more cohesive. One approach is an assignment that requires students to individually reflect on how the interactions among team members have changed over time and formulate a list of members' actions that made a difference, share their lists with team members, and create a written analysis that summarizes the barriers to their team's effectiveness and what was done to overcome them. The

other, and more effective, approach is the same assignment, but students prepare along the way by keeping an ongoing log of observations about how their team has functioned (see Hernandez, 2002).

Learning About Themselves: The Critical Role of Peer Evaluations. One of the most important contributions of TBL is that it creates conditions that can enable students to learn a great deal about the way they interact with others. In large measure, this occurs because of the extensive and intensive interaction within the teams. Over time, members get to know each other's strengths and weaknesses. This makes them better at teaching each other because they can make increasingly accurate assumptions about what a given teammate finds difficult and how best to explain it to that person. In addition, in the vast majority of teams, members develop such strong interpersonal relationships that they feel morally obligated to provide honest feedback to each other to an extent that rarely occurs in other group-based instructional approaches (see Chapter Two, this volume, for examples).

Encouraging the Development of Positive Team Norms. Learning teams will be successful only to the extent that individual members prepare for and attend class. We have learned, however, that when we provide students with ongoing feedback on attendance and individual test scores, the link between preclass preparation and class attendance team performance is so obvious that we can count on norms promoting preclass preparation and attendance pretty much developing on their own. One simple yet effective way to provide such feedback to students is the use of team folders. The folders should contain an ongoing record of each member's attendance, along with the individual and team scores on tests and other assignments (Michaelsen, Knight, and Fink, 2004). The act of recording the scores and attendance data in the team folders is particularly helpful because it ensures that every team member knows how every other team member is doing. Furthermore, promoting public awareness of the team scores fosters norms favoring individual preparation and regular attendance because doing so invariably focuses attention on the fact that there is always a positive relationship between individual preparation and attendance and team performance.

Benefits of Team-Based Learning. In part because of its versatility in dealing with the problems associated with the multiple teaching venues in higher education, TBL produces a wide variety of benefits for students, educational administrators, and individual faculty members who are engaged in the instruction process.

Benefits for Students. In addition to ensuring that students master the basic course content, TBL enables a number of outcomes that are virtually impossible in a lecture-based course format and rarely achieved with any other small group–based instructional approach. When TBL is well implemented, students can progress considerably beyond simply acquiring factual knowledge and achieve a depth of understanding that can come only through solving a series of problems that are too complex for

even the best students to complete through their individual effort. In addition, virtually every student develops a deep and abiding appreciation of the value of teams for solving difficult and complex problems. They can gain profound insights into their strengths and weaknesses as learners and as team members.

Compared to a traditional curriculum, faculty members in a wide variety of contexts have observed that introducing TBL enables at-risk students to successfully complete and stay on track in their course work, probably because of the increased social support or peer tutoring.

Benefits from an Administrative Perspective. Many of the benefits for administrators are related to the social impact of the fact that the vast majority of groups develop into effective learning teams. When team-based learning is well implemented:

- Almost without exception, groups develop into effective self-managed learning teams. As a result, faculty and other professional staff time used for training facilitators and involved in team facilitation is minimal.
- TBL is cost-effective since it can be successfully employed in large classes and across academic programs.
- The kinds of assignments characteristic of TBL reduce the potential for interpersonal hostilities within teams to develop to a point where administrators must deal with the personal, political, and possibly even legal aftermath.

Benefits for Faculty. There is tremendous benefit to faculty who use TBL. Because of the student apathy that seems to be an increasingly common response to traditional lecture-based instruction, even the most dedicated faculty tend to burn out. By contrast, TBL prompts most students to engage in the learning process with a level of energy and enthusiasm that transforms classrooms into places of excitement that are rewarding for both them and the instructor. When team-based learning is well implemented:

- Instructors seldom have to worry about students not being in class or failing to prepare for the work that he or she has planned.
- When students are truly prepared for class, interacting with them is much more like working with colleagues than with the empty vessels who tend to show up in lecture–based courses.
- Because instructors spend much more time listening and observing than making formal presentations, they develop many more personally rewarding relationships with their students.

When the instructor adopts the view that the education process is about learning, not about teaching, instructors and students tend to become true partners in the education process.

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A Compact Introduction to

Team-Based Learning

William D. Roberson and Larry K. Michaelsen (2016)

Welcome to Team-Based Learning

Various paths lead university instructors to Team-Based Learning, but we all have in common two key motivators: 1) the desire to create deep, engaging learning experiences that promote student independence as thinkers; and 2) the desire to make our classrooms places of energy and enjoyment in learning, for our students as well as for ourselves.

Larry Michaelsen originally developed a prototype of what was called "Team Learning" as early as the 1970's in an effort to ensure the benefits of small-group learning in the face of rapidly expanding class size. Bill Roberson, after years of struggle with inconsistent results from student "group work," discovered Team-Based Learning through Michaelsen's early workshops and publications, and finally found in them the means to ensure a positive group dynamic. He has been an avid TBL practitioner ever since.

We have both worked with faculty colleagues who struggled because their teaching failed to engage students, but then suddenly found the tools they needed in the structures and processes of TBL. We also have worked with colleagues who had come to realize, after years of teaching in traditional ways, that their classrooms were having little impact on student learning. When they turned to TBL out of frustration, they discovered in the process that their students were, contrary to outward appearances, highly motivated and intelligent individuals who were hungry for deep learning.

Team-Based Learning is a teaching strategy for creating classrooms that foster student independence and enthusiasm for learning. This short introduction to TBL is a descriptive summary of the essential perspectives, tools and practices you'll need for a first-time successful implementation of the TBL model in your courses. This is not the definitive text on TBL, as it does not provide many examples of specific TBL techniques. We encourage you to use this text as a short-cut reference as you develop your course and lesson plans. For more in-depth information we recommend four publications that provide more fully developed explanations and examples:

- Michaelsen, Knight, and Fink (2004, Stylus), *Team-Based Learning: A transformative use of small groups in college teaching*

- Michaelsen, Parmelee, McMahon and Levine (2008, Stylus), *Team-Based Learning for Health Professions Education*
- Sweet and Michaelsen, eds. (2012, Stylus), *Team-Based Learning in the Social Sciences and Humanities*
- Sibley, Ostafichuk, Roberson and Franchini (2014, Stylus), *Getting Started with Team-Based Learning*.

Additional resources can be found at VIU's web pages dedicated to TBL, on the website of the Team-Based Learning Collaborative (TBLC), https://www.teambasedlearning.org/, and on Jim Sibley's UBC website at http://learntbl.ca/what-is-tbl/.

What does a TBL classroom look like?

Here's a class meeting in Physical Therapy that we recently watched in action.

Sylvia Mitchell enters her classroom on Thursday, just before 9AM. She is pleased to see that all 30 of her students have already gathered and are chatting amongst themselves in their permanent teams (there are 5 of them). She cheerfully makes small talk with students for a few seconds, then starts the class meeting.

"This past Tuesday you took the individual and team RAT (Readiness Assessment Test) on the basic ideas behind creating and choosing treatment plans for clients. Today we're going to look more closely at how those ideas work in reality. Please read the one-page patient data sheet in your folders. Your job is to analyze the situation and condition of this client, and make a determination about how you would respond with treatment, and why."

Students read quietly for about 2 minutes. After students show signs of finishing, she places a slide on the screen and says,

"Here are 4 possible treatment strategies. In your teams I'd like for you to compare and rank them, from most justifiable to least justifiable in this case, given the client data. Be ready to explain why, based on your reading from this past week. Feel free to refer back to your textbooks if you need further clarification of any of the concepts we discussed last time. Write down your team's ranking of these strategies on a piece of paper. You have 10 minutes. Go."

Suddenly the room is loud with a number of voices talking at once. Sylvia wanders about the room listening to the team conversations, but not saying anything to the students. As the 10 minutes come to a close, she glances at the sheets where students are beginning to indicate their ranking of the 4 plans. Most of the 5 teams are close to finished. To the whole room she now says,

"OK, stop. Please take the blue card from your folder and write down the letter of the treatment plan your team selected as ***most justifiable****." The teams finalize their decision*

and write down the number corresponding to their choice. "On the count of 3, please hold up your team's response. One, Two, Three…Show!" 5 cards go up all at once. 3 of them show the same answer, "B." One team answers "C:" and another team answers "D." Sylvia begins the debriefing process by saying, "Interesting spread. Nobody chose A. There seems to be some consensus on that. Mary, what's the reason your team did not put A at the top of your list?

Mary gives an explanation for how treatment plan A ignored a dimension of the case that, according to their readings, is important. Sylvia invites another team to comment ("Did you think the same thing?"), then moves to discussion of the other options: "Let's hear from the team that said "C." Why did you guys conclude that this is a condition that should be treated chemically…?" And so it goes for 20 more minutes, as Silvia asks the teams to respond to each other's reasoning. Through the exchange, Silvia questions (Why? What's your evidence for that? What's your reasoning? How would you respond to that team's argument?) and lets students argue for their analysis and evaluation of the various plans. She facilitates so that students challenge each other's interpretations of key concepts or contradictions in reasoning. She is careful not to divulge her own preference during this exchange.

More than 30 minutes pass in lively analysis and debate, and Silvia now moves toward closure. "I'd like to draw your attention to several important things you said. First of all, kudos to the groups who picked up on the implications of the blood test data. That led you to Plan B, and you made a good case for it. Several of you focused on the patient's present physical condition. That's important to consider, but I'd also suggest you look at the age and history of the patient. That can tell us more than just a snapshot of the present. That longer view might have led us to discount Plan C, and to a lesser extent Plan D. However, several of you saying C and D brought up points worth considering, such as…"

After the summary, Sylvia introduces a new situation: "Let's look at another case, this one a bit more complicated…

What is Team-Based Learning?

In the TBL classroom described above, Sylvia has created conditions where her students can apply and test their preliminary understanding of course content to practice their thinking and gain deeper understanding of the subject matter. She has built a 3-day learning sequence—1) reading, 2) assessment of reading, 3) structured group analysis and decision, 4) whole-class discussion, 5) instructor feedback—around getting students to ***ACT* decisively and concretely on their own** in the kind of situational complexity they might face as experts in their field or professional decision-makers.

Our example was taken from a course in Physical Therapy, but the same principles apply to any discipline. For example, if we had shown a classroom from a History course we would follow the same pattern:

1. Students read to acquire preliminary factual knowledge of events, people, and historical circumstances, as well as knowledge of historical principles, theories and ways to conduct historical inquiry.
2. Students take a short test to verify their basic understanding of what they have read.
3. Students working in teams are presented with a situation that requires them to compare facts, claims, arguments, or artifacts and make a specific, choice/decision about them using knowledge and informed judgements. In a history course students might typically compare interpretations of a document; or competing, contradictory historical accounts; or theoretical arguments in support of various interpretations. In each case the groups work to analyze the given circumstances of the challenge, then make a claim in the form of a decision among options or within parameters provided.
4. The groups' claims are compared through whole class discussion.
5. The instructor facilitates the discussion and provides feedback at the end of the discussion.

Through the use of carefully designed ***application activities*** (#3 in our example from History) students are provided context for their learning, and are asked to put concretely into use what they have learned abstractly from the readings. Connecting abstract concepts from the readings to specific decisions and choices during the team application activities is critical for consolidating student learning and deepening their understanding. Our job as instructor is to find or create these situations, cases and scenarios where what students "know" abstractly (via their readings) is put to the test when they try to "use" it to address a specific challenge.

> **Learning to use knowledge to inform and make significant, specific choices/decisions is the central learning outcome of a Team-Based Learning course.**

The social framework of "teams" facilitates the outcome of improved decision-making. The special TBL format of team application activities (see "4-S" below) ensures that students are fully motivated and receive "immediate feedback" to improve their thinking when confronted with specific choices.

The underlying principle of Team-Based Learning may be counter-intuitive at first to some instructors. In more traditional classroom settings it's a common assumption that if we can get students to adopt productive behaviours (read, prepare, take notes, attend class, pay attention, be quiet, etc.), then we can improve their learning. We may even go so far as to impose rules, policies and

penalties whereby we try to coax or coerce these behaviours. When we focus on "behaviours" rather than "outcomes" however, we can suddenly find ourselves on a slippery slope, and land in the role of a policeman or parent trying to control students.

Team-Based Learning classrooms focus, instead, on goals (outcomes) and performance. The reasoning is simple: if we make the expected outcome clear, indicate what a successful performance looks like, design effective, relevant learning activities for practice, and provide tools for feedback and self-assessment, students will figure out for themselves which behaviours are effective or not. Once students take responsibility for their own performance, they will usually abandon behaviours and attitudes that interfere with or undermine success. It is common to see first-time TBL instructors look on with amazement when students adopt, without being coached or coerced, the habits of careful preparation, regular attendance, and open, respectful collaboration with peers.

What makes TBL work?

Few, if any, of the individual elements of the TBL method are unique to TBL: homework reading, reading comprehension tests, small group work, class discussion, peer feedback, etc. Most university instructors, however they teach, use at least some of these techniques at any given moment. ***The special learning dynamic that TBL produces, however, comes from the systematic, way these practices function together, following a specific sequence and leveraging a few key design principles.***

Consider an analogy with aviation. An airplane pilot follows a specialized protocol in order to land her airplane safely every time. This protocol includes multiple steps, often in a specific, pre-determined sequence, each one contributing to the stable, safe descent of the plane, in consideration of weight, elevation, wind direction, speed, other approaching planes, messages from ground control, etc. Following this explicit protocol—with each step supporting specific dimensions of safety and stability—allows a pilot to accomplish the goal of landing a plane securely in a wide range of dynamic or even hazardous conditions.

Similarly, Team-Based Learning provides instructors with reliable protocols for engaging students and promoting their learning. When understood and respected, the protocols help any instructor—even a brand new one—consistently create rich, engaging student experiences, in a wide range of classroom situations, in any discipline.

CAUTION to NEW ADOPTERS: Improvising major changes to the protocols, without anticipating the consequences downstream, can lead to disappointing outcomes.

Here is an example: in a TBL course students read and take a test on what they read **before** the instructor fully explains it. This practice is called "Readiness Assurance Process" (RAP). Instructors new to TBL may feel uncomfortable with this practice, and may feel obligated (in response to student complaints or pleas for mercy) to give a "helping" lecture or provide another type of crutch before the test.

This seemingly student-friendly change of protocol creates problems and will have negative repercussions later on, in surprising ways. Here's why: the Readiness Assurance Process is not designed solely to check whether students understood the assigned reading. The Readiness Assurance Process is also the first step in socializing the teams—which occurs only through a certain amount of student discomfort and struggle.

The ***Individual*** Readiness Assessment Test (iRAT) comes at the beginning of each TBL learning sequence and occurs without handholding. It challenges students to begin taking personal responsibility for their own learning behaviour. Also, because it is designed to be a slightly difficult, it creates a small amount of "productive frustration" so as to activate the perception that having peers to help might be desirable.

The ***Team*** Readiness Assessment Test (tRAT—which is the same test taken again, as a team) has a different function: it ***replaces*** the instructor's handholding. Students struggle together, learn to coach one another, give mutual feedback, and provide the emotional support needed to prevail through the necessary struggle.

The teams begin to bond when faced with real challenges that are beyond the ability of any single individual. When the team performance beats any individual performance (which is almost always the case), the team effort is validated and team cohesion grows. Over the course of several RAP cycles, students begin to experience their personal responsibility toward their teammates, and increasingly realize that they need to come to class prepared in support of the team.

To non-TBL instructors the RATs might look like any other arbitrary use of a stick to get students to read. In reality, the RAT allows and helps students to enter into their teams as equals with confidence and mutual respect, a fundamental condition for high-performing teams.

When teams fail to gel by mid-term, the reason can often be tracked back to a less-than-rigorous implementation of the Readiness Assurance Process. When students feel that other team members are not prepared and are not pulling their weight—what we commonly call "social loafing" or "hitchhiking"—resentment builds and undermines the team's cohesiveness. In non-TBL uses of student collaboration, this is the number one fatal error: failing to put in place mechanisms to hold individuals accountable for their individual preparation, so that they are able to grow into credible, responsible team members.

In short, a TBL instructor needs to stay fully aware of how the various elements of the method are connected and interdependent. Even though it may feel constricting, **we recommend that instructors new to TBL adhere to the protocols as closely as possible throughout the first implementation**, before improvising changes. Doing so will help you "land the plane" reliably, and navigate toward a classroom that fully promotes student buy-in, self-sufficiency and high-impact learning.

Later, after a first implementation, it should become clearer where creative variations can be introduced without diminishing the targeted outcomes.

The 5 Pillars of Team-Based Learning

TBL is a whole course design and management strategy, not a set of techniques to be sprinkled here and there. As a method, it is not complicated, but it requires disciplined commitment to **5 "pillars" of practice**, each being essential to creating and reinforcing the conditions needed for learning at a high level:

A. **Team formation by the instructor,** to ensure the perception of fairness among teams and diversity within teams
B. **Readiness assurance** to motivate individual preparation and promote student competence for working with peers
C. **Team assignments** designed as student-owned decision-making "applications" of content, both to promote deep learning and to ensure high levels of student interest
D. **Immediate feedback** designed to be the natural consequence of the activities, to stimulate engagement, provoke reflection and accelerate learning
E. **Student agency, self-determination** and **accountability**, to promote a fully ***adult*** culture of learning

This list is intended to summarize for new adopters the rationale behind specific TBL practices. Each of the pillars is elaborated below, following the description of the primary TBL Learning Protocol.

The TBL Learning Protocol

Immediately after Day One of a TBL course, once the permanent teams are formed and students have been introduced to the TBL Model, it's time to launch the first learning sequence, (also called a "module" or "cycle,") which is determined by a specific TBL Protocol. This protocol will be repeated four to seven times over the course of one typical, 12-14 week university term. On average, modules extend over 2 weeks each. In most cases, the 4-7 modules constitute the totality of a TBL course. Compressed courses might require fewer modules, or a shorter timeline for each module.

Step One: Students Read (outside of class, before the in-class part of the module begins)

Step Two: Readiness Assurance Process (RAP) (45-90 minutes)

a) Students take the individual Readiness Assessment Test (iRAT) (closed book, in class)
b) Student teams take the team Readiness Assessment Test (tRAT) (closed book, in class)
c) Students make appeals on unfair, erroneous or ambiguous questions (open book, in class)
d) Instructor addresses student questions, lingering confusion and uncertainties (in class)

Step Three: Application Activities and Assignments (2-4 class meetings)

- Student teams apply content to make analytical decisions (open book, in class)
- Students continue to read, problem-solve and practice individually using content (homework outside class)

Step Four: Assessment of Learning (not necessary for all modules)

- Assessment can include individual or team assignments, or a combination
- Traditional instruments (tests, papers, projects, etc) can be used for individual assessment
- Specially formulated "capstone" case or scenario analysis can be used if some assessment of learning by team is desired

Best Practices for the 5 Pillars of TBL

Pillar A: Team formation

Teams are the focal point for most classroom activities in a TBL course. They are the social motor for learning. Ensuring that teams perform well is not a trivial concern, but the key is in the set-up, not the continual coaching. Teams do not need special training in collaboration or special team-building exercises when the conditions are properly set by the instructor. Here are the key "socializing" practices for every TBL instructor.

1. **Teams are permanent over the whole term.** Learning to function as a team takes time. For some teams, it may take weeks for members to learn to work together.
2. **Teams need to be formed immediately at the outset of the course (On Day One, if at all possible)** to communicate clearly the new expectations. You'll need a plan for determining how late-registering students will join existing teams.
3. **Team membership needs to be assigned, not self-selected,** to establish a sense of fairness and to weaken existing alliances. It's best if the team formation process can happen in public. Transparency contributes to the trust and confidence needed for rapid team cohesion.
4. **Teams need to be large (optimally 5-7 members)** in order to have diversity of perspective and depth of resources.
5. **Team formation should ensure even distribution of student assets and liabilities relevant to the course outcomes.** For example, in a course in environmental science, you might want to distribute students with a strong foundational background in chemistry or biology. See the protocol for team formation, below, for ideas on how to accomplish this.
6. **Optional Practice: Teams benefit from giving their team a name,** to reinforce their identity. Using this name regularly in classroom conversations can further help with the process of bonding.
7. **Teams need to be assigned an engaging, decision-based team activity <u>as soon as they have met</u>** for the first time. There are several options. Setting grade weights for the course, determining criteria for "helping behaviour," doing a mini-RAP based on the course syllabus, or a content-related team activity (See 4-S activity design, below) are all potential candidates for a first-day activity that gives students their initial taste of the TBL classroom.

Pillar B: Readiness Assurance

The protocol for the Readiness Assurance Process (RAP) includes 4 steps, which are most powerful when they occur ***face-to-face*** and ***in immediate succession***.

Each element of the RAP has *at least* one critical objective, and therefore should not be omitted:

i. The **iRAT (Individual Readiness Assessment Test)** is a short, closed-book, multiple-choice test that holds students individually accountable for their own efforts to understand course content. The iRAT is the basis for effective team member behaviour.

ii. The **tRAT (Team Readiness Assessment Test)** is a repeat of the iRAT, also closed-book, written immediately after the iRAT, but taken as a team. It fosters team skills by requiring negotiation, and furthers team development by showing students the value of their teams, who almost always outscore any individual.

"Immediate feedback" on team answers is critical for team development. Immediate feedback can be provided by projecting the answer key on a screen at the end of the tRAT. Alternatively, if available, the use of scratch-off (IF-AT™) answer sheets (purchased through Epstein Education) is especially effective. Visit www.epsteineducation.com to see a wide variety of "lottery-style" answer sheets for different formats of multiple choice questions.

iii. The **Appeals** process follows immediately the tRAT, and invites students to challenge test items that may be flawed, in order to show students that they own their learning, and need to defend it. Teams must submit their appeals in writing and provide evidence and sound reasoning for each appeal.

iv. The instructor's **Clarification**, after the submission of appeals, usually takes the form of a class discussion or short mini-lecture, if needed. This step allows students to get expert feedback *directed to their specific questions* and concerns, but should not turn into an extended lecture. ***Do NOT review the whole RAT—discuss only the questions that everyone missed.***

Key practices for the Readiness Assurance Process (RAP)

1. **The RAP occurs, without exception, at the very beginning of every cycle or module of the course**. (A TBL course typically has 4-7 cycles or modules, in contrast to many traditional courses that are organized by 12-14 separate, weekly units of content).

2. **Do not administer a RAP more often than 6-7 times in a typical 14-week semester.** Overuse of RATs will visibly erode student enthusiasm and motivation for your course.

3. **The reading amount for one RAP needs to provide enough substantial material** to feed team application activities over one whole module (approximately 2-4 class meetings or 3-8 contact hours). The actual amount will vary discipline by discipline and by density of material, so a reading assignment could be 20-30 (dense, highly technical) pages on the low end and 100-300+ pages (such as a whole collection of articles, several textbook chapters, or a whole novel) on the high end. ***It may be necessary to show students early in the course how to read strategically, for broad, contextualized understanding when faced with larger reading assignments.***

4. **Readiness Assessment Test (RAT) questions should target understanding of important concepts, not picky details.** RATs should not be comprehensive exams, but rather a ***sampling*** of student understanding of key ideas and critical differentiations. 10-20 items are sufficient in most cases. A smaller number of high quality, carefully written, challenging questions is the best approach.

5. **Both the iRAT and tRAT are closed-book, in-class tests.** The richness of team discussion during the tRAT comes in part from the members' struggle to reconstruct from memory their understanding of what they read. If students need access to specific technical information from the readings (formulas, equations, obscure values that should not be memorized, for example) to support their thinking, these can be provided with the questions, but be careful that the RAT does not focus on narrow analyses with calculations or the like, as these types of questions will not be highly effective in the tRAT discussion. Keep the questions at the level of conceptual understanding of and differentiation among key concepts.

6. **RAT questions are always in a multiple choice or true-false** answer format in order to create the conditions needed for dynamic team decision-making and immediate feedback during the tRAT. Open-ended questions do not force the kinds of negotiation and convergent thinking that teams need in order to develop as teams. Remember that multiple choice questions can be made highly complex and challenging, by basing them on situations or mini-cases, rather than on factual recall.

7. **Within one RAT, questions should be distributed over levels of difficulty.** See Bloom's Taxonomy for ideas on writing questions at different levels. A few items should be easy to build confidence; a few items need to be hard (complex, ambiguous, nuanced) enough to elicit rich team discussion.

8. **RATs should be challenging. It's better to administer RATs that are slightly too difficult rather than too easy.** Too easy means boredom and low incentive because there's nothing at stake—and one really gifted member can carry the group. Excessively hard means loss of motivation as students can begin to feel that success is out of reach. **Target individual scores averaging 50-70%, with team score averages targeting 80-95%.**

9. **RATs should be administered with time limits.** A 10-question iRAT can usually be written in 6-10 minutes; the tRAT discussion for the same test will generally need 15-20 minutes. These will vary depending on difficulty of the test and the specific population of students. It's important to keep some pressure on students, so aim for the low end, then adjust if needed. A good rule for keeping students on track: once half the teams have finished, the remaining teams have just two minutes more before grades will be calculated and posted.

10. **tRAT scores should be published** on the board or screen for the whole class to see, as part of the feedback process. This allows teams to monitor their own learning and creates a fun, softly competitive atmosphere. In many cases students will alter their expectations of themselves and increase their commitment to preparation when they see how other teams are performing.

11. **The Appeals process should be conducted during the same class meeting in which the RAP occurs.** Do not skip the appeals step and do not make it appear optional or unimportant. Students need to develop the expectation that they, alone, are responsible for evaluating the quality and accuracy of the RAT as a measure of their preliminary understanding of the reading.

    Do not ask, "Are there any appeals?" Rather, create the expectation for appeals. At the end of the tRAT tell students they have 5 minutes to determine which items they wish to appeal. Then give them another 10 minutes or more to write down and submit the reasons for the appeal. If some teams elect not to appeal any questions, have a new assignment or activity ready to keep them productive while the other teams finish.

Pillar C: Team Application Activities

Team application activities in the shape of comparative analysis leading to concrete "decisions" or "specific choices" are the single most important element of Team-Based Learning.

Decisions not only translate knowledge into actions, they are the mechanisms for generating student interest, curiosity and engagement.

Because students have fulfilled their part of the bargain and are known to be prepared (via the Readiness Assurance Process), they need to be challenged in ways that allow them to see for themselves the usefulness of what they have studied. Team application activities need to be hard enough, and contain enough uncertainty or complexity, that the most diligent student cannot simply answer because he/she knows a lot. Design team application activities around decisions that require students to use not only their new knowledge, but also their reasoning and their judgment.

The protocol for developing Team Application Activities is called "4-S" (originally called "3-S" in Michaelsen's original writings) .

I. Conceive the task so that it looks **Significant and therefore interesting *from the student's perspective***. This means that the task will ask students to USE their new knowledge (from the readings) actively in responding to specific, concrete situations. Seeing the immediate utility and relevance of what they have just read is highly empowering and motivating.

II. Require students to think comparatively and make a **Specific choice** among several possible options. This forces students to weigh competing priorities, values, arguments, interpretations, theories and the relevance of specific facts, in making their decision. The answer parameters allow the instructor to anticipate and target the specific terms and concerns of the discussion.

III. Require all teams to work on the **Same** task, so that, when they report their answers to the whole class, they will be able to compare their own response to those of the other teams—for immediate feedback. In this comparative framework, students will naturally and genuinely care about how the other teams responded.

IV. Use report-out techniques allowing **Simultaneous** responses for all teams. When all teams report simultaneously, the comparison is dramatic

and the natural outcome is that groups are fully engaged: they want feedback from and are willing to give feedback to each other. See the practices described below for examples on how to conduct simultaneous reporting.

When the teams have made a specific choice in relation to the same significant problem, and then discover via a simultaneous report that other teams made a *different* choice, they are both motivated and intellectually prepared to challenge other teams' answers and defend their own. The instructor then facilitates a comparative, analytical discussion of all answers, where the teams are asked to defend their thinking and respond to one another.

Proven best practices for ***Design*** of Team Application Activities

1. **Start with a verb.** If you can find the verb that represents a significant action requiring knowledge of course content (evaluate, assess, diagnose, predict, contrast, compare, rank, categorize, critique, etc.), you're on your way to a good application task. Do not design activities around verbs of state, such as "understand," and "know" or low-level tasks such as "identify", "find" or "match." Team application activities need to be framed as concrete actions in unfamiliar circumstances and new situations, so students can see for themselves the applicability, portability and impact of their knowledge.

2. **Find ideas for team application tasks by looking at what people who work in your discipline do with their knowledge.** Ask, "What kinds of problems do we try to solve? What kinds of questions do we try to answer? How do we use our discipline's information and ideas?" Ask your students to make the kinds of judgments, interpretations, evaluations, predictions and other types of decisions that you, yourself, and other professionals or academics do as the regular part of your work. For example, from our opening story from Physical Therapy, "Look at the data summary provided for this client. Assess and rank the various treatment plans according to their relevance in this case." From History: "Which of the various theoretical explanations of this event is the most convincing?"

3. **Develop Team Application tasks that…**
   …are based on responses to cases, scenarios, concrete problems, actual questions and inquiries. The goal of a team task is to lead students to "test" and stretch their knowledge by trying to use it in complex, realistic situations.

…ask for the comparative analysis and assessment of objects, statements, claims, theories, arguments, representations, images and other products or tools typical of your field.

4. **Team responses, including those applied to complex scenarios and questions, should be converted to a single, easily visible, focused representation**—letter; number; single word or phrase; image; chart, graph, bullet list—so they can be easily compared across all teams for immediate feedback during the Simultaneous Response phase. The most common technique for simultaneous reporting is to ask teams to reveal their specific choice responses using colored, numbered, or lettered cards. This can also be done using blank sheets of paper, where students write down the letter or number or word of their selection and hold them up at the moment of reveal. Small, hand-held whiteboards also work for this purpose. Clickers can be used, but they are less effective than cards, since they do not communicate immediately and publicly teams' visible ownership of their answers.

   For responses where students are asked to represent their decisions graphically (draw an image or chart) it works well to have teams record their work on poster paper, then simultaneously publish it by attaching it to the wall at a given signal. In these cases, students can then conduct a "gallery walk," in which they roam the room assessing the other team's answers, before engaging in a whole-class, comparative discussion of all responses. For more details on these and other reporting techniques, please see Chapter Seven of *Getting Started with Team-Based Learning*.

5. **Make sure some team application activities count for points or marks.** Mix application tasks that are "formative" or "developmental" (no points) with those that are designed to be capstone-like "challenges" or "show us what you can do" tasks that are scored for points. This ensures accountability for the team's work. A good practice is to do a series of non-scored tasks leading up to the task that is graded.

Proven best practices for M*anagement of* Team Application Activities

1. **Limit the time you allow teams for making their collective decision during an activity**, and if possible, use a visible timer (Power Point can be adapted to this purpose). Tell the teams that they will need to produce an answer at the end of the given, announced time limit, whether they have finished discussing or not.

2. **Do not assign teams a sequence of several tasks at the same time** (as in a worksheet or list of questions, for example) as this will kill all the energy of both the team discussion and the whole-class discussion. Separate team tasks into clear, single decisions, present them individually, one by one, and discuss fully before moving to the next. For long sequences of activities that include some non-4-S activities, consider alternating individual work (e.g., worksheets or problem sets) with focused team 4-S decision tasks that require conceptual, convergent thinking that is built upon the individual work.

3. **Manage the task by projecting instructions, questions or other prompts on a screen, or by using paper handouts**. This keeps you from having to shout over a loud classroom once discussion is underway.

4. **Leave the teams alone while they are working on a task.** Move around so as to be seen, but so as not to be drawn into a conversation. Do not invite yourself into a team conversation, and deflect questions asking for special help.

5. **If students from one team ask a question during a team activity, push it back to the whole team to consider, if possible.**

6. **If you need to clarify an element of an activity, clarify for the whole class, not for just one team.**

7. **Make the simultaneous report crisp**. (On the count of 3: 1-2-3…SHOW). This will help students see and benefit from the immediate feedback provided by other teams' responses, and will reduce fudging by teams who are uncommitted.

Proven best practices for *Facilitation* of Application Activity Discussions

While 4-S Activity Design ensures student engagement in high levels of thinking, ***the actual learning itself is dependent upon effective facilitation by the***

instructor. It is the facilitation process that frames and fosters the in-depth analysis, feedback and reflection. The instructor's role should be that of inquirer, not director. Teams need to be invited to explain their reasoning and defend it vis-à-vis the claims and evidence provided by other teams. An effective facilitator will use questions and "naïve" re-statements of students' claims, to entice students to discover for themselves the consequences of their team decisions. For that purpose, here are a few guidelines for facilitation.

1. **Keep a poker face during facilitation**. Maintain the appearance that all responses could be valid or correct until all have been explained by the teams who represent them. Many an excellent discussion has been undermined by the instructor tipping her hand as to what she considers a "correct" or best answer to be, even before all the teams have finished reporting. It's good practice to let students go down a wrong path, to fully expose their reasoning. When it's finally time for your feedback, point to the strengths of the various team responses, even while pointing students towards a "best" response.

2. **It does not matter if all teams agree** and report the same, "best" or "correct" answer. The learning occurs during the discussion. Teams may have different reasons for arriving at the same answer. Your first response to a simultaneous report, no matter the spread of team answers, is some version of "Why?" directed at one of the teams.

3. **Cluster team answers when you debrief**. If three teams answer the same way, collect reasons from one of these, then ask the others if they have something to add (Don't proceed one by one). This avoids tedious, repeated explanations.

4. **Vary your order of collecting team answers**. If you always start with the worst one, students will catch on. Sometimes start with the best one. Starting with the minority opinion is often a good strategy, as it ensures that unpopular arguments will be heard.

5. **Close the discussion by pointing to what has been learned**. Make sure to indicate any merit in students' arguments, even if their overall reasoning was flawed.

6. **If a final, correct or best answer needs to be presented, offer it as "this is what the experts would say,"** so you, personally, will not always be identified as the only source of knowledge and authority.

Pillar D: Immediate feedback

Seeing for ourselves the consequences and impact of our own actions is the most powerful teacher that exists. This is the psychology that informs game design. Games, like TBL classrooms, are learning systems, where each action by a player (or team of players) generates consequences that provide the feedback that teaches. A hockey player shoots at the goal and watches to see if the goalie can stop the puck. A poker player makes a bet and watches to see how the other players respond. A video gamer watches how opponents on the screen respond to moves, then alters his strategy or tries a different tool. In any game, a player watches and responds to the effects of his actions—immediate feedback—then takes what he has ***learned*** into consideration when planning future moves.

> ***TBL protocols and practices are specifically designed to create a classroom experience rich with "immediate feedback."***

When the immediate feedback to a team is positive ("We got it right!" "We got more points than the other teams!") it validates team decisions that are sound, and therefore helps the team bond through greater confidence and a stronger sense of identity. When the feedback is negative (for example, when the team misses a question on the tRAT) it can have a useful corrective effect, and help team processes by affecting both the members who might be too assertive or too quiet.

When teams receive feedback that their choice is incorrect, members who may have had good ideas but were reluctant to speak up while the choice was being made realize that they let their team down. Further, even if none of the other team members have any idea about the fact that there was missing input, the quiet members recognize the negative consequences of their inaction, and are motivated to speak up in the future.

Also, during 4-S activity and discussion, when team members are struggling with getting an overly assertive member to listen and have therefore ended up with a problematic "team" answer, the immediate feedback provided by the entire class in the simultaneous report and subsequent discussion helps them make their point.

Here are the 3 primary practices of TBL that are designed to generate immediate feedback:

1. **Immediate feedback will occur for individuals, when transitioning from iRAT to tRAT.** When students finish their iRAT and turn to the tRAT, they are bombarded with immediate feedback, as they begin comparing

their own answers with those of their teammates. Disagreements among team members lead immediately to analytic inquiry (Why did you say A?) and self-assessment (Am I sure of what I read, understood or remember?).

2. **Immediate feedback will occur for teams through the tRAT scratch-off (IF-AT) process.** The tRAT scratch-off form makes the consequences for team decisions immediately visible. This ensures that a team will assess its effectiveness at the end of each negotiation leading to an answer. The immediacy of the feedback allows team members to evaluate the effectiveness of their own decision-making, and to change any behaviours—either collectively or of individuals—required to improve the performance on subsequent items.

3. **Immediate feedback will occur for everyone during team application activities.** The formatting of 4-S team application tasks for "same-problem + simultaneous response" is specifically conceived for generating immediate feedback.

   "Same Problem" ensures that, however the teams respond, their choice will become relevant feedback for the other teams.

   "Simultaneous Response" ensures that each team will see immediately where they stand* vis-a-vis *the other teams. No one can hide from his own thinking.

   The **simultaneous response** reveal is a critical moment of deep self-assessment. When a team is alone in its report of an answer, it immediately feels challenged, and will respond in a variety of ways, all productive. It might argue forcefully and find value in defending itself against the other teams. If the team felt unsure to begin with, the soul searching begins when team members see the responses of all the other teams. Because teams have had to commit to an answer and report it in public, however, they have no choice but to make their case. In some situations they will be vindicated, as the minority position may turn out to be a good one.

Pillar E: Student agency, self-determination and accountability

Students need to be treated like adults, who are free to act on their own judgment, based on knowing what is expected of them to achieve a goal. This means a major shift away from teaching practices characterized by "controlling" students, where the instructor's personal needs, preferences and even worries and fears can inform how the course is experienced by students. A well-managed TBL course ensures that students ***own*** the course. Students are assumed to be self-motivated (even if they don't appear to be on the surface!), intelligent, capable, responsible individuals, and are, accordingly, objectively accountable at multiple levels. Here are key practices that promote a learning culture for adults.

1. **Course policies are written so as to place students in the role of "agent" acting in his/her own interest.** To achieve this culture means communicating to students the **choices** they are free to make, and the **consequences** that come with those choices, whatever they may be.
   a) Eliminate "attendance requirements," but replace them with "productivity accountability." Students who choose not to attend class are free to do so, knowing that they accept as a consequence loss of the opportunity to receive credit for work done during class. We recommend making sure that something significant gets marked and recorded frequently in class.
   b) Eliminate "make up" assignments. Instead, give students license (and choice!) to drop a small, fixed number of scores in each category of their grade, so that they can be responsible for managing their own options to do or not do an assignment. (You'll need policy language to deal with dire cases of catastrophic illnesses or accidents).
   c) Provide students with assignment deadlines expressed as "choices" tied to "levels of "eligibility" to receive points. For example, assignments submitted by a given date would be eligible for specific point values; assignments submitted on a later date would be welcome, but eligible for fewer points. Avoid the language of "penalties" for late assignments or other infractions. Penalties are perceived by students as the instructor's arbitrary exercise of authority and control. Build your policy structure around the choices students are free to make, knowing that they—and they alone—are accountable for the consequences.
   d) Explain in the course syllabus (and make sure students read it—such as through a first-day "practice RAT" on the syllabus) how your course gives students the tools and responsibility to manage their time as they find necessary.

2. **Students evaluate their teammates' "helping behaviour"** as a part of the course grade. If students are going to become fully responsible and accountable for their team's learning, they will need leverage to motivate their peers to be effective partners.
   a) The Peer Evaluation component of the final course mark should be somewhere around 5-10 % of course total, although there might be circumstances in which more is appropriate. The amount needs to be high enough to potentially influence a student's final grade for the course, but not so high as to directly determine the final grade, by itself.
   b) Spend time on Day One or Day Two of the term working with students to determine the criteria to be used in assessing peer helping behaviour. This works well as a first team activity on day one. See Michaelsen, Knight, and Fink (2004), for a description of the fishbowl exercise often used to establish behaviour criteria for the whole class.
   c) Schedule a first peer feedback and evaluation exercise approximately 1/3 way in the course. Use this activity to allow students to provide feedback to one another, with no points at stake.
   d) For the final peer evaluation, choose a process that requires students to differentiate among individuals in assigning scores to their peers.

3. **The overall grading scheme includes weights or percentages for individual work, team work, and peer evaluation.** The specific weights will vary from course to course and from instructor to instructor, depending upon learning outcomes and the students' frame of reference. The culture of the institution and age or maturity of the students, for example, might affect the grading scheme and weighting strategy you use.
   a) Give student teams the opportunity to determine at least some of the grade weights (within parameters you give them) during the first week of the course. A common, minimal practice is to let students decide the weight of the iRAT vs the tRAT. Let them choose, for example, a 50-50, 60-40 or 75-25 weight split, in either direction. All teams have to agree to the same weighting scheme. See Sibley *et. al.* (2014) for elaboration on this procedure.
   b) As you become comfortable with this process, you can let teams help you determine the value of grade weights for the whole course, within certain parameters. A description of how to do this can be found in Michaelsen, Knight, and Fink (2004).
   c) For the course as a whole, it is recommended for new adopters to start with an overall target weighting scheme of approximately 60-70% for individual work and 30-40% for team-based assignments. As a rule, keep the individual weight aggregate total well above 50%, to ensure individual accountability. As you become more comfortable with the TBL model, you might find reasons to shift the balance of weights in one direction or another.

d) Make sure that some of the daily team application activities result in a score that counts toward the course grade. One way to do this is to have students record in writing and turn in their team response and reasoning, **before the simultaneous response** and subsequent class-wide discussion. The instructor can then evaluate the team's response and enter a value in the grade book.

Here is a sample grading scheme for a TBL course. Note that there are several traditional components. Individual tests and papers, for example, can still be part of a TBL course.

20%	RATs; (Individual vs. Team fraction to be determined in class)
10%	Weekly in-class team "Challenge" activities
20%	Individual in-class Essays/Midterms
25%	Individual Capstone Essay/Memo (or "Final Exam")
20%	Capstone Team Case/Situation Analysis
5%	Team Member Performance (Helping behaviour--peer graded)
100%	Total

This will work!

For many instructors, the first implementation of a TBL course will be an invigorating and satisfying intellectual challenge. Don't worry if you don't hit all the marks perfectly the first time you use TBL. And don't be deterred by the few students who may struggle in response to the new expectations you have communicated. It's perfectly natural for a few students to push back at first—this is a positive sign that you have gotten their attention and are challenging them in a meaningful way. Be prepared to explain to students that your course is designed to teach them how to use their knowledge, which will prepare them for real-world challenges.

This is a learning process for both you and your students. Students in general will be forgiving when they notice (and they will!) that you are trying to create for them an engaging experience, and that they are learning more than they would in a lecture-based course. We hear stories from faculty members who tell of how their students became partners in the process, offering feedback during the course on how to improve RATs as well as the design of 4-S activities that did not work as planned.

Your goal for a first time effort is to put the basic TBL protocol in place, respecting the 5 pillars of practice, and fine tune as you go. It's common, for example, to struggle at first with designing consistently effective team application activities around meaningful choices and decisions that generate lively, relevant

discussion. For some instructors, calibration of RAT difficulty (too easy *vs.* too hard) is also something to be learned through practice. Above all, it's common to struggle in adapting to an outcomes-driven course, where the design of student work in their teams forces you to "think backward" to make sure all the pieces are in real alignment, from the clarity of learning outcomes, to the design of 4-S application activities, to the creation of the RATs, to the selection of content.

There will be genuine joy in the effort, however. We are reminded of a colleague who recently commented to us, during her first semester of TBL, "The discussions in class have been inspiring: this is the first time in my teaching career that I've actually been able to ***see and hear*** my students learning!"

These students could be yours. Trust the method.

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Twelve tips for doing effective Team-Based Learning (TBL)

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Abstract

Team-based learning (TBL) in medical education has emerged over the past few years as an instructional strategy to enhance active learning and critical thinking – even in large, basic science courses. Although TBL consistently improves academic outcomes by shifting the instructional focus from knowledge transmission to knowledge application, it also addresses several professional competencies that cannot be achieved or evaluated through lecture-based instruction. These 12 tips provide the reader with a set of specific recommendations which, if followed, will ensure the successful design and implementation of TBL for a unit of study.

Introduction

Medical educators have long recognized two important realities. One is that being able to recite all the subtle differences between one form of a disease and another is a very different kind of knowledge than being able to quickly diagnose the correct form of that disease suffered by a real, living patient. The other is that medical students must master both kinds of knowledge.

In traditional medical education, students were exposed to the two different kinds of knowledge at different times and in different settings. The content was typically taught in lecture-based courses and, later (some years later) students learned to use the content during their time in clinical rotations.

Delaying students' opportunity to learn to use the content, however, does not fit well with what we now know about how adults learn best – the kind of learning that both 'sticks' and can be transferred to novel situations. As a result, medical educators have experimented with a number of approaches for enabling students to more closely connect the content and concept acquisition with its application – e.g. problem-based learning (PBL), case presentation.

The purpose of this article is to describe an approach that, like PBL, immediately and intensively engages students with the kinds of problems they will encounter in medical practice. With this approach, team-based learning (TBL), some classroom time is spent on ensuring that students master the course content. However, the major emphasis is on concept application, and the processes through which students learn both the content and the applications are specifically designed so that student groups develop into *self-managed learning teams*. As a result, a single instructor can both provide content expertise and oversee the learning endeavors of an entire class.

For a course with TBL as part of its learning activities, students are strategically organized into permanent groups (for the entire term of the course) and the course content is organized into major units (typically five to seven). Before *each* in-class event, students must study assigned materials because each module begins with the readiness assurance process (RAP). The RAP consists of a short test (over the key content and concepts from the readings or other activities, e.g. dissection) which students first complete as individuals, then they take the exact same test again as a team, coming to consensus on each question. Students receive immediate feedback on the team test and they then have the opportunity to write evidence-based appeals if they feel they can make valid arguments for their answers to questions which they got wrong. The final step in the RAP could be a 'lecture' (usually very short and always very specific) to enable the instructor to clarify any misperceptions that become apparent during the team test and the appeals, but also could be a between-team discussion about why the selected correct answers are best – fielded by the instructor. Once the RAP is completed, the remainder (and the majority) of the learning module is spent on in-class activities and assignments that require students to practice *using* the course content by solving challenging problems.

TWELVE TIPS

Tip 1: Start with good course design

TBL is an instructional strategy that works best when it is integrated *tightly* with a course's design. It can be the primary mode of instruction or work alongside other learning activities, i.e. focused lecture, service learning, self-directed online tutorials. We recommend using Dee Fink's *Creating Significant Learning Experiences: An Integrated Approach to Designing College Courses* (2003) for guidance in defining a course's (or curriculum's) contextual issues, goals, assessments, learning activities, and feedback mechanisms. Often, instructors will 'try out' a TBL module or two in an existing course, either replacing a set of lectures or small group sessions that had required recruiting and herding many faculties. This is a valid way to gain experience with how to implement it, but, usually, it is hard to incorporate the peer evaluation component since the number of meetings will be few.

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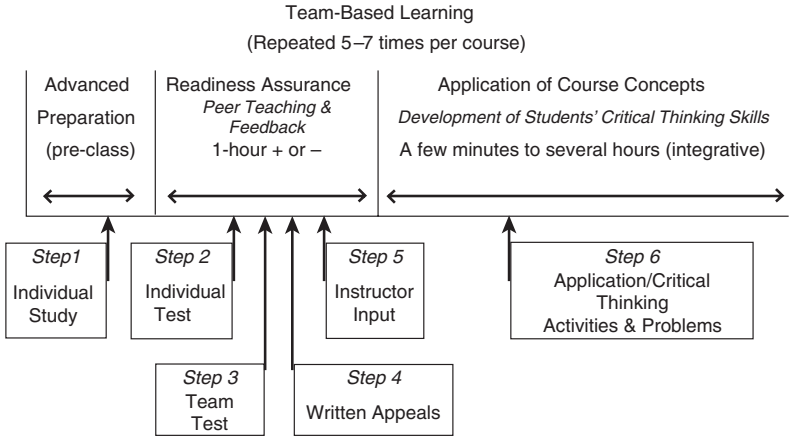

Figure 1. Instructional activity sequence for TBL content unit.

Tip 2: Use a 'backwards design' when developing TBL courses and modules

With backwards design (Wiggins & McTighe 1998) the first question to ask yourself is, 'What do I want my students to be able to DO by the end of this unit of study?' Whether designing a single TBL module for a unit of study, e.g. Starling's Law and cardiovascular physiology, or a series of modules that form the basis of an entire course, clarify what you want the students to be able to do by the end of the module or course. For example, a goal for a module in physiology/pharmacology focused on Starling's Law would be for the students to be able to apply their understanding of Starling's law to accurately interpret physiologic data from a case of congestive heart failure, explain how Starling's Law governs which findings, predict which pharmacologic agent will affect specific components of heart function. A traditional course in anatomy would have many TBL modules, each one presenting a new clinical problem vignette linked to the cadaver dissection component of the course and giving the students multiple opportunities to learn the daily applicability of anatomy knowledge for clinical practice.

This single question is often the hardest one for instructors who are 'content-driven' to ask themselves. There is just so much 'content' that we feel our students must know before they can make use of it – but, TBL provides a way to have them master the content while they are applying it and get feedback on how well they are 'getting it' as they go.

Tip 3: Make sure you organize the module activities so that students can reach your learning goals and you (and they) will know that they have done it

After clarifying what you want your students to be able to do by the end of the module, the next step in backwards design is creating a group application exercise. This should be a problem that requires students to use all of the preparatory knowledge and their team's brainpower to analyze, interpret, and then commit to a choice or a decision. Further, you should avoid the temptation to ask a series of questions as a means of 'leading students through the thinking process.' It is far better to require them to make a difficult choice and let them work together to master the concepts and to discover and internalize the relationships between them in the process of coming to a conclusion.

Once you have decided what you want students to be able to do and how you will assess whether or not they can do it, the next two steps in backwards design are identifying what content elements the class must master before they are 'ready' to solve the problem (i.e. the information that the students need to learn outside of class to be prepared for the module) and write the questions for the readiness assurance test (RAT) (and do not call it a quiz – its purpose is readiness assurance and you should emphasize its role by the terms you use in talking about it).

Tip 4: Have application exercises that promote both deep thinking and engaged, content-focused discussion

Over the years, we have come to realize that the single most important aspect of successfully implementing TBL is what your assignments require students to create. Whatever the content, if you ask them to produce a lengthy document, they will divide up the work which, in turn, will reduce learning and, all too often, will result in negative feelings about their peers and skepticism about working in a group. On the other hand, we have learned that, by using well-designed assignments, students will both learn from each other and develop a great deal of confidence in the value of working in a team.

The key to designing effective assignments is ensuring that what students are asked to do is characterized by 4 S's at each of the stages in which they engage with the course

content – working alone, working within their team, and working across teams (i.e. whole-class discussion). The 4 S's are:

Significant Problem

For a successful group application exercise, select or create a problem that the student can readily recognize as the kind of problem that will be encountered in 'real life,' make it **S**ignificant. In medical education, this is easy – there are an infinite number of patient cases that are rich with data to be interpreted, decisions to be made. But, there has to be a clear link between the content that underlies the exercise and its application. At the conclusion of the hypothetical module on Starling's law/physiology, you want to hear your students talking about how the basic principles of the law are applicable to understanding cardiac contractility in stress situations and how to approach interventions. In addition, the answers to these questions should never be discoverable in a text or article or lecture notes – they can only come from team members collaborating to figure them out.

Same Problem

With TBL, all of the small groups must be working on the **S**ame Problem. If you assign different problems to different small groups, students are not accountable to each other because you lose the benefit of having any semblance of a robust discussion (and learning!) between-group discussion of the problem. Further, if you allow groups to choose their own problem, they are not even accountable to you – unless you are willing to do the research that you hope they would do.

Specific Choice

When your assignments require students to agree on a specific choice, the only way they can accomplish the task is by working together to critically appraise a situation, examine the existing evidence, and make a professional judgment. Further, the more specific the question, the better the learning. For instance, if your module was about depression and pharmacologic interventions, a good question would be 'Identify the set of neurotransmitters that are affected by the best drug choice for this patient' and not 'What would be the best drug for this patient' because a more specific question requires a deeper analysis.

Simultaneous Report

You create an important 'moment of truth' when all the small groups are asked to post their responses to a question at the same time. Two things happen *as soon as students realize that the choice they will be making will be open to challenges from other groups*. One is that, because of the potential of an 'us versus them' situation, group cohesiveness increases. The other is that students are far more engaged in the within-groups discussion because they realize that they would not be able to hide if they do not 'get it right.' In addition, by engaging students exploring how they arrived at their respective answers, you can readily create a class discussion that is far more informative to you and your students than asking, 'Somebody say what they think about thus-and-such.'

Individual versus Team Readiness Assurance Test Scores*

- In the majority of classes, the lowest team score will be higher than the highest individual score in the entire class.
- Overall, approximately 4% of the individual scores will be higher than the lowest team score in a class.
- Teams will outscore their own very best member 99.9+ percent of the time (i.e., 1,114 of 1,115 teams).

*Based on 30 years of data from 6,161 students in 1,115 teams.

Figure 2. RAT scores.

We have also learned two lessons – sometimes by sad experience – about the 4 S's. One is that failing to do *any one* of the 4 S's substantially reduces both the intensity of class discussions and the resultant learning. The other is that, if you fail to do *any two* of the 4 S's, learning is minimal and pretty much the only reason that students are willing to complete the assignment is that it will have a negative impact on their grade.

Tip 5: Do not underestimate the importance of the RAP

The RAP is designed to link students' advance preparation to the group application exercises and provides a remarkable and powerful opportunity for individual feedback and peer teaching within the teams. In addition, the RAP lets you (and the students) know if you need to address gaps in their understanding. If the content area is particularly difficult, e.g. autonomics, odds ratios and predictive values in critical appraisal, liver pathology, then the RAP should be separated in time from the group application exercise so that the instructor can give corrective feedback and/or provide additional input before they begin to tackle the group application exercise. However, you do not have to cover everything – only what you (and the students) know they need help with.

The RAP, when done well, unfailingly produces five priceless outcomes even though it typically uses only a fraction of the overall class time (usually about 25–30%) for any given unit of instruction. These are:

(1) Effective and efficient content coverage.
(2) Development of real teams and students' interpersonal and teamwork skills.
(3) Students gain an experience-based insight about the value of diverse input.
(4) Development of students' self-study and life-long learning skills.

(5) Class time during which you can provide the content expertise to ensure that students develop critical thinking skills.

In addition, data from the RAP provides data that definitively answers the question of whether or not individuals are likely to be held back by working in teams. Based on data from the past 23 years of using TBL (Michaelsen and Parmelee, unpublished), teams will score higher than their own very best member 99.9+% of the time[1] and the most common outcome is that the worst team score will be higher than the highest individual score in an entire class.

Unfortunately, we have seen some instructors miss out on part or all of these valuable outcomes because they have, for whatever reason, decided to: (1) skip either the individual or the group component – or both; (2) use questions that are merely designed see if the students did the reading, e.g. asking 'picky' or meaningless questions unrelated to the objectives of the module; and (3) view this process as a way of getting another assessment for their course grade. The RAP is not just another 'quiz' and neither instructors nor students will reap its many potential benefits if it is treated as such.

Tip 6: Orient the class to why you are using TBL and how it is different from previous experience they may have had with learning groups

Most students will not have had a classroom experience like TBL. In fact, the majority of their experience with group work will have been struggling to complete poorly designed assignments that forced them into the uncomfortable position of having to choose between doing more than their fair share or risk getting a bad grade and/or having to deal with difficult group members just to get anything done at all.

These concerns are real and must be addressed or you will have a difficult time getting student buy-in unless students understand both why you are using TBL and how TBL is designed to avoid the problems that they, all too often, have come to expect are a normal outcome from doing group work. At a minimum, you need to outline your course objectives and provide an explanation of how they would be achieved in a traditionally taught course *versus* how you will achieve them by using TBL. Other suggestions to help them understand and accept TBL include: (1) giving a practice RAT (many use the course syllabus as the 'subject matter' for the test); (2) engaging them in the process of determining the grading system for the course (Michaelsen et al. 2004) and, throughout the course; and (3) reminding them about the benefits they are experiencing along the way.

Tip 7: Highlight accountability as the cornerstone of TBL

The cornerstone of success of TBL is that the natural outcome of its processes is that individuals, teams, and the instructor are immediately and clearly accountable for behaving in ways that promote learning. Students are accountable for coming to class, preparing before they come, and investing time and effort working in their team. The instructor is accountable for providing students with the cognitive foundation they will need to be ready to tackle the kinds of problems they will face in medical practice and giving them opportunities to practice developing their application skills.

When TBL is fully employed, the vast majority of students are prepared, come to class, and engage each other in productive ways as they work together. As a result, even the students who start out with a skeptical attitude because of past negative experiences with learning groups will eventually embrace TBL – 'Finally, hard work as an individual and hard work as a group pays off.'

As for the accountability of the instructor, some students will inevitably start out with the impression that he/she is not 'teaching' as in other classes, i.e. using lectures to state what will be on the final exam, and, worse, we (the students) are having to do all the work. Further, if the instructor is not following through with his/her side of the bargain – doing a good job of: (1) providing students with the opportunity to practice using well-designed applications assignments (i.e. using the 4 S's) and (2) reminding students of the benefits that they are getting – then the doubts and the resentment are likely to persist.

Tip 8: Providing a fair appeals process will inspire further learning

Inevitably, some students will disagree with your selection of a best answer on a RAT question. They will do so on one of two bases: the question was written in such as way that they were confused or they feel you made an error in your interpretation of the content. The appeals process (Michaelsen 2008, p.24) provides the opportunity, preferably while they are still in class, to either re-write a question that they feel was poorly written or articulate, in writing, why they feel their answer was better, using references if appropriate. Accept appeals from a team only; award credit to the appealing team(s) only and to the individual scores of the members of those teams.

The appeals process provides a number of benefits. One is that it motivates students to do a focused re-study of the exact material that gave them the most trouble. Another is that, the process of trying to put together a successful appeal requires to think deeply about both the specific ideas and the overall context within which they reside. Finally, students can often re-write your questions so that indeed they are better!

Tip 9: Peer evaluation is a challenge to get going, but it can enhance the accountability of the process

There are several ways to set up a peer evaluation process for the course, and it may take some trial and error to find the one that fits well with your institution or course's culture (Levine RE 2008, Chapter 9). There are, however, numerous benefits from putting forth the effort. One of the most important is that, when you use peer evaluations, students are accountable to the members of their team. Another is that a well-designed peer evaluation process enables students to learn how to give

constructive feedback to one another and to gratefully receive constructive feedback from peers – an invaluable competency for future practice.

Tip 10: Be clear and focused with the advanced preparation

A criticism of TBL is that the instructor identifies the learning needs for the students, thereby robbing them of the opportunity to explore the potential domain of the content and make some judgments about what they need to know. Based on past experience, when you are specific about what you want them to master before a TBL module, including posting action-oriented objectives such as 'Be able to articulate how dopamine affects sodium channels at the receptor level,' you invite them to go beyond doing the minimum of preparation since that will only help for the individual part of the RAP. They learn quickly that for their team to be really successful in the group work, they must master the advance assignment assiduously and devote additional effort to exploring the content domain. Tying the TBL objectives to the course objectives is essential.

Tip 11: Create the teams thoughtfully

We have three principles to guide the process of getting a class into teams: (1) make the process transparent so all students know how they ended up in a particular team, even if the process is totally random; (2) distribute what you define as 'resources' for a team as evenly as possible, for instance, a beginning class of medical students might have several students who have advanced degrees in one of the basic medical sciences, so you want to assign them to different teams; and (3) strive for the teams to have a diverse composition, i.e. gender balance, rural or urban backgrounds, science/nonscience majors. Letting a class know that teams that have diversity within, however defined, will have unique strengths to draw upon in the challenging modules ahead.

Tip 12: Several low-budget 'props' facilitate the implementation of a good module

One does not need to spend several thousands of Euros for the latest audience response system or any high-definition technology to get a well-constructed TBL module to work. We recommend using IFAT™ response forms for the group readiness assurance because students will hover over the scratch-off card, talk with each other, make eye contact, and be passionate about whether or not the correct answer is going to emerge. They receive immediate feedback, let one another know things like 'You were right! Next time make us listen to you!' Prepare folders for each team, color code the components to make the sequence of activities clear, collect everything so that you do not have to start 'de nova' every year – a good module is a treasure. Buy or build flagpoles to demarcate the position of teams; laminate the lettered cards for simultaneous responses. Require students to stand and face the class when speaking – you will not need a roving microphone once they learn to be quiet when someone is speaking.

Conclusions

We are grateful to have been invited to provide these 12 TIPS. Over the past few years, we have provided many faculty development workshops and consultations, around the world, to introduce medical educators to TBL and assist them with its implementation in a variety of settings. In most cases, TBL has produced a positive transformation of the classroom experience for both the students and the instructor. Sometimes, however, we hear comments from faculty such as: 'I tried it a few times, but gave up because the students didn't like it,' or 'Does one have to use all the components? The GRAT sounds like a waste of time.' Unfortunately, whenever we ask about the details of a less-than-successful attempt, we almost always learn that one or more of the components had been omitted or altered substantially. The strategy has been well tested and works, but works best when all of the components are included in the design and implementation.

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Note

1. Based on data from 6161 students in 1115 teams since 1986–1114 team scores were higher than the score of their own very best member.

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Effective Task Design for the TBL Classroom

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Group and team tasks are the culminating outputs of student learning in team and collaborative learning environments. How they are conceived and designed, therefore, can directly determine the success of the pedagogical strategy. A key design issue for creating effective tasks is how best to focus student knowledge, observation, and analysis toward a concrete action that makes thinking visible. Actions in the shape of clear decisions applied to complex scenarios, within a restricted framework of options, are most likely to channel student thinking toward higher-level goals. The authors provide principles and examples for designing group tasks in any discipline.

Introduction

Effective task design and management are at the heart of team-based learning (TBL). Whether or not the Readiness Assurance Process (the TBL process of testing students on their attempt to cover a unit of content on their own) is successful in preparing students to apply what they know, it is the collective decision making required by team tasks that truly focuses student learning, provides traction in the learning process, induces team cohesion, and stimulates general student enthusiasm. If the tasks are not carefully conceived and challenging in the right way, student focus drifts, classroom energy falls off, and teams fail to cohere. For this reason, task design should be a first concern for an instructor transitioning from more traditional teaching to TBL. Effective design and implementation of tasks can offset many problems, and can even carry to partial success an otherwise flawed TBL implementation. The purpose of this article is to

frame the challenge of task design conceptually, extract some principles based on that conceptualization, and offer examples showing how the principles can be put into practice in a range of disciplines.

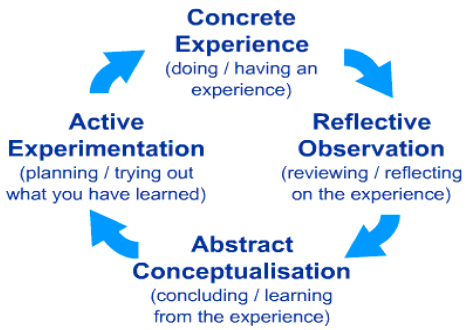
Tasks Make Learning Visible

A central tenet of TBL is that student learning is driven through frequent and, whenever possible, immediate feedback. In order for this to happen, student learning and consequent use of that learning in their thinking have to be made visible—to students themselves as well as to the instructor. Students, therefore, need to be required to *act* frequently in ways that generate consequences that provoke reflection and demonstrate visibly their thinking. The more focused and concrete the action, the more visible will be the thinking and the learning—and the more immediately useful will be the feedback.

Recent findings in neuroscience, cognitive science and psychology can help us visualize this key role of action in the learning process. Bransford (2000), for example, emphasizes the essential difference between understanding and memorization, citing numerous studies showing that simple rote learning does not lead to transfer of knowledge. Cognitive psychologist Willingham (2009) argues that "Memory is the residue of thought" (p. 54), meaning that thoughts are made manifest by actions, and only acting on information can transfer it from working memory to long-term memory. The work of neuroscientist Zull (2002 and 2011) reinforces these findings, showing that learning that has not been put into the service of action tends to remain dormant and through disuse becomes less retrievable from storage in the brain's neuronal networks.

Much of this work builds on earlier studies in psychology, namely Kolb's theory of experiential learning, depicted in Figure 1. This idea of the learning cycle is a useful guide in thinking about the process we are trying to foster in our students' cognitive functioning. The conception of learning as a cycle helps us to envision how our knowledge of the brain can be translated into successful classroom practice. In Kolb's description, the experience of an action leads to observing and reflecting on its consequences. This reflection is the first step in abstracting from the experience a conceptual understanding of what happened and what it might have meant. As abstract theorizing develops, opportunities for experimentation with the use of that knowledge should follow so that students can put their abstract understanding to the test. It is this ongoing interplay between abstract conceptualization and active, concrete experience that creates the possibility of storing learning and applying it to new situations.

Figure 1
The Kolb Experiential Learning Cycle
(from McLeod, 2010)



In the college classroom, one of the instructor's most important jobs is to design and *stage* opportunities for students to undergo this cyclical action-reflection-conceptualization-action process so that relevant information and ideas become fully networked in the brain. A comparable level of fully networked understanding is extremely difficult to build through less-active means—by sitting through a lecture, for example, or watching a video or reading a text. Our students need to construct their own conceptual understanding within the framework of active individual experience. Each action we ask them to take leads to reflection and greater awareness, which, in turn, leads to receptiveness to new information, integration of that information, and planning for new, more informed actions. In essence, we are helping our students work toward becoming more intentional and more expert in their thinking and actions, particularly with respect to our discipline. The assigned tasks that induce these actions drive learning. They, therefore, need to be integrally connected to the larger, overarching strategy of the course and directly tied to course learning goals.

Course Design, Task Design, and Disciplinary Thinking

More traditional, instructor-centric teaching practices tend to shape courses and curricula around disciplinary content. Syllabi are routinely

structured as sequences of topics that will be covered from week to week, and often track to textbooks with similar patterns. This approach to content can sometimes be a barrier to deep learning, as it does not capture the full scope of what it means to work and think within a discipline. The signature of a discipline, whether in the humanities, sciences, social sciences, or professional fields, is less its content (which might be shared among several disciplines) than its actions. Historians are historians not just because they deal with historical texts and artifacts, but because they use historical resources to inform actions that are typical of historians, such as reconstruction of a past event, evaluation of the influence of a particular person, and the like. Sociologists might (and often do) use those very same historical resources to inform a different set of actions, such as in the analysis of a contemporary sociological condition or the determination of how a social injustice came to exist. An economist might use the same resources yet again to inform her construction of a predictive model of behavior in a given set of market conditions.

A bit further afield, but no less relevant, an epidemiologist, trying to track the evolution of a virus over time, might have reason to explore these same historical resources because they contain evidence of behavior and circumstances related to the emergence of a pandemic. Specific information ("content") does not suffice to define a discipline. Disciplines are more clearly defined by how those working within the discipline collect, organize, assess, and use information.

The real difference, therefore, between novice and expert thinkers in our disciplines is not determined by the amount of information they have covered or even mastered, but rather by their relative ability to interact with that information. Course and task design need to be pointing students not toward simply knowing more, but ultimately toward more refined, more expert ways of responding to and using information. If we want our students to become more expert in our disciplines, we need to structure their encounters with content in ways that change what they can *do* with knowledge.

Implications for Task Design

The most clarifying action a student can take is to make a decision. Requiring collective decision-making provides an opportunity for students to practice the kind of thinking we want to promote in our courses and disciplines and is the starting point for effective overall TBL course design. A well-constructed decision-based task integrates components of higher-order thinking: analysis of the particular situation to deter-

mine competing priorities and values; various lines of reasoning; use of relevant concepts, principles, laws, or other abstractions at play in the situation; reflective, critical thinking *(Are we sure of these facts? Are we sure we understand?);* and, ultimately, a judgment that is expressed in a visible, concrete action/outcome that can be evaluated. Effective team tasks point students consistently toward making decisions that reveal reasoning and understanding in service of a judgment. The judgment students make ideally will replicate as much as possible the kinds of judgments made by disciplinary thinkers.

In order to put students on this track, we first need to identify and characterize the kinds of actions and decisions that thinkers in our disciplines execute frequently. Then we can reverse engineer situations where students practice doing these very things. In this way, we ensure that students also practice using the targeted disciplinary content of the course. Here are some key questions that can help us begin the process:

- What do people in your discipline do with the information they collect and/or use? What kinds of problems do they try to solve?
- What is characteristic about the way practitioners of your discipline think—that is, how do they approach and enter problem-solving? How do they reason?
- What kinds of judgments do experts in your discipline have to make?
- What assumptions consistently inform their decisions and other actions?
- What are the discipline-specific actions and types of decisions that a successful student will be ready to carry out as a result of your course?

Jotting down several items for each of these questions will help instructors characterize and eventually locate or invent the types of tasks that will be relevant to the learning targets of their course. What follows are a few basic examples of decision-making in various disciplines.

- *Economics*: Decide which patterns of buyer behavior can be determined from a given set of consumer data.
- *Sociology*: Decide what might be the implications of a new data set for understanding a specific social phenomenon.

- *Philosophy*: Decide whether a given action is just or rational, according to specific criteria or values.
- *Business*: Decide which marketing strategy to use, given background data and consumer circumstances.
- *Literature*: Decide what patterns an author has constructed to influence reader perceptions.
- *Writing and Rhetoric*: Decide which evidence would work best to support a given thesis.
- *History*: Decide which account of an historical event is most convincing, given competing perspectives and evidence.
- *Biology*: Decide (predict) which environmental conditions will most alter an organism's DNA.
- *Chemistry*: Decide (predict) how a given molecular structure will be changed by contact with other specific types of molecules.
- *Math*: Decide which variables are significant or which calculation strategy will produce the most valid or accurate result.

From this macro perspective, in which we identify globally what students need to be doing daily in order to practice disciplinary thinking, we are ready to move to the micro-level and look at more specific elements of task design. The most successful TBL courses are those in which the instructor maintains the macro-micro perspectival exchange throughout the course. Keeping an eye trained on the macro while working on the micro will also facilitate the selection of material and formats for team tasks and other assignments. The daily, specific team tasks need to inform and align with the bigger actions (such as major graded assignments)—and vice versa.

Situating Team Tasks in a Learning Sequence

For tasks to be perceived as authentic and valuable learning opportunities, students need a clear sense that they are serving the stated learning goals and disciplinary thinking goals considered above. This is particularly true when we want to challenge students at a high level, such as by asking them to make decisions that they perceive to be above their current level

of expertise. If they do not value the kind of thinking we are asking them to practice, they may be resistant to the challenge. In this context, tasks serve various tactical purposes at different times.

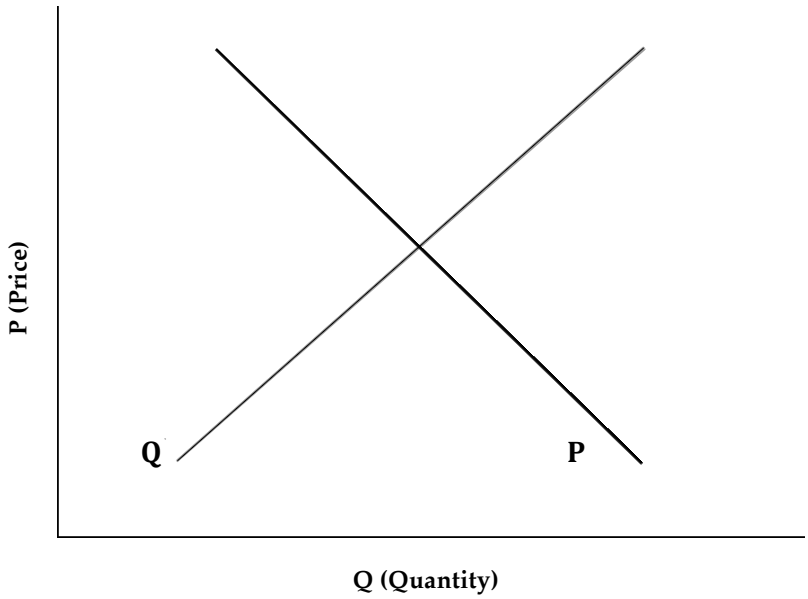
Before the RAP: Use Naïve Tasks to Launch a Learning Sequence

A common source of pushback early in a TBL course is students' mistaken belief (sometimes unintentionally reinforced by a "helpful" instructor) that they cannot do the reading on their own. In the face of resistance, many instructors will instinctually move toward one of two problematic practices: (1) giving students a highly detailed reading guide or set of questions to answer or (2) lecturing before the I-RAT. Either of these will undermine the goals of TBL. One way to avert this situation is the use of *naïve* tasks.

Naïve tasks occur at the very beginning of a learning sequence—even before the reading assignment—and are designed to induce an attitude of inquiry. When designed and managed appropriately, they serve to challenge students to test their preconceptions and practice their reasoning before being exposed to the targeted unit of content. In this way, naïve tasks serve to surface pre-existing errors in student thinking. More important, though, making and defending a decision before having access to key information promotes the perception that the information, when it is eventually provided, will be a valuable tool or resource. Consequently, students will be more likely to undertake the reading assignment with greater enthusiasm because the readings are no longer a mere requirement. They are, instead, perceived by students as being useful for the purpose of assessing and improving their own thinking.

Naïve tasks provoke curiosity and function as a kind of reading guide without becoming a crutch that reinforces students' learned helplessness the way more direct instruction can do. Reading with a specific, self-corrective purpose also replicates the way actual experts (and our brains in general) approach and respond to new information. The naïve task strategy therefore supports the long-term goal for students to begin honing their intuitions about thinking in the discipline. The example below is a naïve task from a course in economics. It can be used to introduce the fundamental concept of "elasticity" or as practice to develop deeper understanding after a general conceptual introduction. This task can be set up using a graph and a brief explanation of how the axes and curves show schematically the supply and demand relation to price within any given market. For example, Figure 2 illustrates elasticity as a concept used for measuring how likely change in a given market factor (for instance, quantity/supply) might influence another factor (for instance, demand/price).

Figure 2
Elasticity



Students are then asked to choose an answer to the following:

> Which of the following will NOT cause a shift in the demand curve for ice cream?
>
> A. The government gives every family $500 tax rebates.
>
> B. The price of frozen yogurt doubles.
>
> C. There is report that milk products used to produce ice cream have special health benefits.
>
> D. The price increases by $1.
>
> E. None of the above—these all cause shifts in demand.
>
> (*example supplied by Shawn Bushway, Criminal Justice, University at Albany*)

After students have proposed and debated possible answers to this question with their teams in class, they are ready to tackle the reading, which is a more systematic presentation of market forces. Because the naïve task has already driven students to grapple with the concepts presented in the reading, they will now read actively, with an eye toward the kinds of judgments and decisions they will be able to make, once they have understood the new information.

Here are some sample naïve tasks from other disciplines:

- *History*: Read this paragraph (from an unknown source). In which decade do you think it was written? Why?
- *Anatomy*: Look at this photo of a liver. What does it suggest about the health condition of the person it belongs to? Why?
- *Literature*: Read this paragraph. Predict the actions and fate of the character you see described, based on the limited information provided (and be ready to say why.)
- *Engineering*: Look at this design of a bridge. In an earthquake, which element is most at risk of failure? Why?
- *Computer Science*: Look at this sequence of code. Which series of actions is it designed to execute in the robot? Why?
- Various disciplines: Read this specific claim/statement. Which of the following theories does it appear to represent/support?

While naïve team tasks can be used at the very beginning of the RAP before students have read, they can also be used during the "informed" application task phase of a sequence. In the latter case, naïve tasks prepare students for new concepts that build on those already encountered in the core readings (discussed below).

Finding the appropriate level of difficulty for naive tasks is essential to their success: The tasks need to require a real judgment and a concrete decision based on that judgment rather than merely ask students to supply or apply basic knowledge. By asking students to act in the face of "insufficient information," naïve tasks validate the role of information when it finally lands. In order to create room for information, a naïve task needs to be difficult enough that most teams will struggle and likely arrive at the wrong answer at first.

Beyond the level of difficulty of the task, cultivating an atmosphere of playfulness is essential to encourage teams to persist in the face of this difficulty. Students have to feel an intrinsic reward for "playing along" and even getting the wrong answer. Handling wrong answers is also a crucial moment for instructors—we need to acknowledge their errors in thinking while demonstrating that with more information, the challenge we have presented is surmountable. Finally, a publicly reported team decision is essential so that students are held accountable for their current thinking (like experts and professionals) and have an opportunity to re-examine their position in light of other students' responses to the same challenge.

Because naive tasks are intended to induce reflection and surface common student misconceptions rather than evaluate students' final level of learning, and because students need encouragement to take risks in their thinking, the stakes for naïve tasks should remain low. This means that they will most likely be ungraded, or at most be good for bonus points, in order to minimize the perceived cost of error. The psychological support of the team is also a fundamental component of naïve tasks. The team structure allows students to be less self-conscious about errors than when they feel they are individually accountable.

After the RAP: "Informed" Tasks That Put Knowledge to Use

An essential difference between a traditional course and one designed for TBL is the role of content. In a TBL course, acquisition of course content/knowledge is not the primary learning goal, but it is the vehicle for students to practice specific ways of thinking and acting. "Informed" tasks, as opposed to naïve ones, ask students to convert their reading, understanding, and reasoning into judgments and clear decisions that make the learning and thought process visible.

There are multiple levels of informed tasks, and one of the first challenges facing new TBL adopters is creating lower-level tasks that require real judgments and authentic decisions rather than simple plug-in responses. It is important to keep in mind that the Readiness Assurance Process has confirmed basic understanding, and this does not need to be repeated. Tasks that aim too low and ask only for basic recall/recognition/rote memorization create little opportunity for meaningful struggle. These tasks will often lead the most diligent students on the team to dominate the conversations because they can simply rely on their memory or superior reading skills, and less diligent students will learn that they can freeload. This will not only undercut intellectual development, but will also compromise team cohesion.

Assessing basic understanding is typically best suited for individuals (in a homework task, for example). However, if the instructor does decide to review basic understanding of concepts using team tasks, these should minimally ask students to *interpret* or *translate* ideas and information so as to demonstrate understanding rather than recall. Lower-level application tasks, which ask students to *transfer* conceptual knowledge to concrete situations and specific examples, also can be used to review and/or confirm basic understanding.

Bloom's Taxonomy (1956) is the best-known model for classifying learning objectives by level of intellectual challenge. The simplified version in Figure 3 is a useful distillation of the taxonomy into three basic cognitive levels and suggests some types of tasks that will lead to actions corresponding to each category.

What follows are some elaborated suggestions for framing tasks that address skills at the various levels.

Knowledge/Comprehension (framed as interpretation, transfer, and simple application):

- Rank the following statements from most to least effective in summarizing the author's argument about X. (interpretation)
- Assign the following new statement to one of the three categories identified by the author. (transfer, simple application)
- According to the chapter, which of the following (new statements) would be an acceptable definition of X? (interpretation)
- According to the reading, which of the following (new items) would be the best example of concept X? (transfer, simple application)
- *Physics*: According to the reading, which kind of stress is most likely to be at work when force is applied at point A in the following (new) diagram? (transfer, simple application)
- *History*: Now that you know the definition of "dynasty" from the readings, which of the following (new) examples from history is most representative of the concept? (transfer, simple application)

Figure 3
Bloom's Taxonomy (Simplified)

Synthesis/Evaluation	• Predict consequences • Predict patterns • Make judgments
Application/Analysis	• Find causes • Find patterns •Conduct comparisons
Knowledge/Comprehension	• Recall information • Restate accurately • Translate into new language

- *Social Work*: Which theory covered in the reading provides the best explanation of what occurred in this (new) case of child abuse? (transfer, simple application)

Analysis (framed as comparison, contrast, analytical differentiation):

- Which factor in the given list below would you weigh most heavily in a diagnosis of X (a new case)?
- Which of the following theories (that you just read about) would be most useful in predicting the outcomes of this (new) process?
- Which of the following (new) statements is consistent/not consistent with the writer's perspective?
- Which of the following claims about X phenomenon could be explained/defended/refuted by an application of Y theory?

The highest-level tasks require more complex processing and use of knowledge. They target broader judgments that reference multiple factors and thereby call for expert-like decision-making:

Advanced Analysis, Synthesis, and Evaluation (framed as expert-like judgments that integrate understanding for complex decisions):

- Rank the following strategies/recommendations / explanations in terms of which would be the most effective, in light of the theories we just read about.
- Given the facts of this scenario, and the competing priorities, decide upon which of the following recommendations you would make first.
- Analyze this new data set: Based on the theories covered in the reading, and given what you now know about X, which of the following explanatory hypotheses has the most credibility?
- Based on the facts as you now interpret them, evaluate the relative truth of the following claims by ranking them.

As most of these latter examples show, one reliable technique for writing higher-level tasks is to think in terms of situations, scenarios and cases that are typically encountered in the discipline. Brookfield (2011) provides an effective overview, with examples, of "Scenario Analysis" techniques, in *Teaching for Critical Thinking*. Scenarios allow you to embed many variables that can be used to introduce multiple concepts, theories and perspectives into students' discussion, as well as to complicate the task, if desired, through a mix of relevant factors and red herrings.

Promoting Critical Thinking Through Task Design

Critical thinking is a productive consequence of intellectual frustration. It begins to occur at that moment where knowledge, insight, reasoning, and other assets prove to be inadequate for addressing with complete confidence the problem at hand: Students are forced to make a decision that stretches them. This is the moment where they will finally adopt a critical thinking attitude and ask themselves, "What are we really sure of? Are we making the right assumptions? Are we overlooking something because we are biased? Have we exhausted all possibilities? Do we have access to any additional information? What does our best judgment tell us? What are the potential consequences of any of our possible actions? Which of those consequences are we most willing to accept?"

The emergence of critical thinking in the TBL classroom is closely interwoven with the building of team coherence. Team coherence and critical thinking both develop when students are forced to consider, respect, evaluate, and respond to the positions and ideas of other team members. This rarely occurs when the task is open-ended, such as in a brainstorm

or other "generate solutions" assignments. As long is as it is possible to believe that "one idea is just as good as another—we don't need to evaluate and prioritize," many students (and most humans!) will shy away from the hard work of real thinking.

The function of the collective decision task, therefore, is to place a restrictive frame around the team's action. This restriction forces the team to evaluate, integrate and, if needed, respectfully discount a team member's inputs *en route* to a judgment and a focused decision. A sound idea, a persuasive line of reasoning or a convincing argument will eventually emerge when it withstands the critique of all team members. As the team's coherence develops, so do the comfort, freedom and willingness of individual members of the team to speak frankly about the value of any other team member's idea.

A secondary but nevertheless important dimension of this centripetal pressure on teams is time limitation. As long as students have the impression that a decision can be deferred or deflected ("we don't have enough time, so we give up"; "we need more information, so we won't respond") critical thinking will not readily occur. Time limits on tasks and the expectation that reporting will happen, finished or not, are therefore essential.

Finally, a crucial element of the critical-thinking process is making mistakes: if students are to develop an attitude of persistence in the face of difficulty, they must become experienced in confronting and reflecting candidly on the errors in their thinking. This means that it is essential for teachers to balance the pressures created by forced decisions and time limits with a healthy respect for honest, thoughtful mistakes. In fact, instructors must force students to make errors that will create opportunities for careful consideration of where their prior knowledge and ways of thinking are insufficient. Creating this atmosphere requires a mix of graded and ungraded team tasks, careful attention to team-building, and strategic debriefing of tasks to induce productive reflection. The 4-S principles of task design are essential to fostering this environment.

Principles of Task Design: Elaboration on Michaelsen's 4 S's

We begin this section by referencing the original framework for TBL task design, conceived first by Michaelsen, Knight, and Fink (2004) as the 3-S's, then later revised by Michaelsen and Sweet (2008) to become the 4-S's:

- Significant problem
- Specific choice

- Same problem
- Simultaneous report

The longer we have worked with these principles, the more relevant and empowering they have proven to be. Each of the S's captures a necessary dimension of task design and management. "Significant problem" and "specific choice" establish how the task will be drawn from content and structured for student action. "Same problem" and "simultaneous report" address how the task will be administered and managed. In the following paragraphs, we seek to build out from these principles, by elaborating on their original rationale and by supplying some examples of how they can be operationalized.

1. Significant Problem: Selecting Content for a Task

What is truly problematic in your field and in the content you are teaching? What is difficult to understand fully and to resolve? In order for students to engage with your content at a high level, they have to believe that what they are struggling to do really matters. Tasks, therefore, need to address questions that are compelling in your discipline. The best tasks ask students to make judgments and decisions that parallel those of experts exposed to similar (or, at least, parallel, analogous) circumstances, conditions and information. A truly *significant problem* is, ideally, one where the teams' responses may not fully resolve the issue; they serve mainly as the pretext and entry point for inquiry and reflection. In fact, the very best problems (which may or may not be within the scope of your particular course) point toward disagreements among experts in the field—problems where different paths can lead to credible and defensible solutions.

When the problem is significant, real learning occurs during the debriefing of the task. If the debriefing discussion ends shortly after students show their answers, the challenge may not have been sufficiently problematic or, therefore, truly significant. In the best of cases, there will be substantial disagreement among the teams, but even when all teams have chosen the "correct" or "best" answer, a truly significant problem can still lead to a lively discussion in the debrief, as students will still need to explain and justify their thought processes, which may vary across teams.

Tasks that can be accomplished by applying simple knowledge in a single-step reasoning process to arrive at an answer are unlikely to challenge students meaningfully. Similarly, tasks that simply elicit an opinion, impression, or personal perspective will fall short of the mark. Tasks that allow students to stumble upon a correct answer without having engaged

in a rigorous thought process are destined to be trivial. *To be effective and authentically significant a task has to lead students to a decision point that invites—and may even demand—the question "Why?"* "Why?" is the doorway to course content and disciplinary thinking—and to meaningful inter-team conversations.

2. Specific Choice: Delimiting Student Action

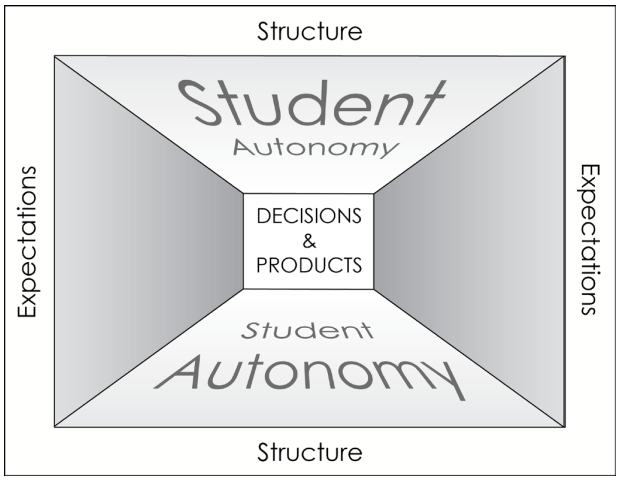
Our instincts sometimes tell us that the best way to lead students toward a full exploration of multiple perspectives is to start discussions with a wide-ranging question or set of questions that will open several possible avenues of inquiry. Whenever we tell students to "discuss," we envision that they will use the collective wisdom of their group to converge toward meaningful possibilities. The problem with this approach among relative novices is that they often take the conversation in directions that may not be highly productive. Contrary to our instincts, we need to shape and stage student conversations around tasks that more carefully direct them toward a productive outcome, a *specific choice*. Figure 4 uses the image of a tunnel to communicate the dynamic of an effective discussion. At the outset of the process is the frame that establishes the field of action. The format of the question structures the discussion and sets expectations for how it will be reported. At the other end of the process is the moment of public accountability, in the form of the proposed solution (product or decision) that emerges from the team discussion. Between these two moments, the teams experience a sense of relative autonomy. They are free to exploit any means at their disposal to find and evaluate all relevant possibilities in the process of reaching the conclusion supported by all team members.

Tasks that direct students toward a specific choice do not stifle student thinking but concentrate it so that feedback on the task can be directed at specific, anticipated discoveries and realizations. Restricted decision making allows the instructor to ensure the terms of the whole class debrief. The forced compare-and-select approach means that students will be engaged in very specific points of analysis during the team decision-making process. A broader-ranging discussion can follow during the task debrief, after students have begun to sort through the possibilities that the instructor has provided.

What follows is an example of how a typical discussion prompt becomes a TBL question. Consider a typical group discussion prompt (from a course in sociology):

> Discuss the factors that Karlsen, writing in *The Devil in the Shape of the Woman*, argues are relevant in an accusation of witchcraft. What seems to be important?"

Figure 4
The Shape of the Learning Process in a TBL Course



A TBL decision task prompt could read as follows:

> Based on your reading in Carol Karlsen's *The Devil in the Shape of the Woman*, which of the following would she consider the most relevant factor in an accusation of witchcraft?
>
> A. Accuser's concern with maleficium
>
> B. Accuser's gender
>
> C. Accuser's relationship with clergy
>
> D. Accused's relationship with clergy
>
> E. Accused's age

Here we have pointed the teams' conversations to a limited set of possibilities, and in doing so we have ensured that students will weigh exactly the factors we want them to weigh. If there are other issues that are important, we will have the opportunity to bring those out in the debrief of the team answers.

The example above demonstrates one obvious strategy for creating specific choice tasks: multiple-choice questions. Below are several other

formats that can also lead to simultaneously reportable, focused choices.

Ranking: Rank the following solutions in order of their plausibility (Debrief: Report highest or lowest).

Sorting: In the envelope on your table are strips of paper, each listing a statement about X phenomenon. Sort them according to the 4 theories we have been studying (Debrief: Report whole solutions on poster; or, ask students to announce by show of cards how they categorized an individual item).

Scoring: Read the following excerpt. On a scale of 1-4, assign a score that indicates how successfully this writer has applied X principle.

Sequencing (chronological; procedural; logical; narrative): Place the following events from American history in chronological order; or place the following steps in the order that represents the most effective procedure for solving X problem.

True/False: Evaluate the following statements and decide as a team whether they are true or false. Be prepared to explain and defend your team's answers:

- Humans are more highly evolved than ants.
- Over time, species evolve into better or more highly evolved species.

(*example supplied by Kristina Spaulding, Psychology, University at Albany*)

What does not belong? Look at this slide (not shown) that lists nine consumer behaviors. With your team, select the five (or three, etc.) behaviors that research has shown to be most greatly affected by an economic downturn.

Matching: Figure 5 provides an example of a task based on matching.

3. Same Problem: Strategic Task Administration

Same problem can be one of the least intuitive elements of 4-S design, because it runs counter to many traditional beliefs about teaching. As information in the disciplines continues to expand, we feel increasing pressure to "cover" as much content as we possibly can in any given class period. Well-meaning instructors may believe that one way to achieve this coverage—and to remove ourselves from the center of our classrooms—is to create situations where students "teach" each other. To achieve this,

Figure 5
Matching

Match the claims in list 1 with the correct causal mechanisms in list 2.

List 1: Claim	*List 2: Causal Mechanism*
A. Farm subsidies increase production.	1. Slaughterhouses have become fewer and larger.
B. Market concentration in food production and distribution leads to increased subsidies.	2. The policy lowers the cost per unit, which leads to an increase in demand for the good.
C. High corn yields cause negative externalities, such as pollution runoff.	3. HFCS lowers the cost of soda, which increases consumption.
D. E coli infections have increased dramatically.	4. Fertilizers and pesticides increase production per acre.
E. Corn subsidies increase child obesity.	5. Many former executives served in the USDA and FDA.

(*Example supplied by David Rousseau, Rockefeller College of Public Affairs & Policy, University at Albany*)

we divvy up tasks, asking each group to be responsible for one element of the content and then to share their findings with the rest of the class. But when it comes time to report and "teach" the others, there is little intrinsic motivation for students to care or listen. Rather than inspiring curiosity about what the other groups have to say, the divide-and-conquer approach actually quells it. Students are forced to sit through reports and discussions that have no immediate relevance to them.

Students *are* interested in what their peers have to say when they themselves have a stake in the conversation. If all teams are at work on the same task, the learning moment will be the debriefing of team responses, which begins with comparison of those responses across teams. When a team can see that "We were sure we were right, but our answer is different from everyone else's!" they are ready to listen to their peers and participate in a learning conversation. Their egos and emotions are engaged. They have an authentic desire to know: "How did you arrive at that answer? What about X? Why didn't you consider Y?"

4. Simultaneous Report

Now that all teams are working on the same task, the logic of a dramatic, *simultaneous report* becomes evident. It is useful for the instructor to adopt a visualization method that works well consistently: cards, posters, personal response systems (clickers), whiteboard "reveal," or other mechanism. Experience has convinced us that cards or other visual tools work better than clickers for this purpose. While clickers can be used to simultaneously report team decisions, they fail to provide the crucial sense of immediacy and dramatic ownership that comes when students hold up cards or sheets showing how they decided, *vis à vis* the other teams.

Aside from the theatrical flourish that brings energy to the classroom, simultaneous report has a more fundamental function in the learning process: public, highly visible accountability that levels the playing field for all students in the room. Students need to see how their thinking compares to that of others in order to reflect candidly and self-assess. If teams are asked to report their responses sequentially, rather than simultaneously, students can fall into the trap of self-deception: their ideas can conveniently and comfortably morph to those that belong to whichever group's report seems most convincing or most admired by the instructor. In this case, the opportunity for real self-assessment is lost. Sequential reporting also introduces the risk that students will begin off-task side conversations and fail to pay attention to or participate in the whole class discussion.

Consistently creating tasks that allow for simultaneous report is a chal-

lenge for instructors new to TBL. In some cases (for example, multiple choice questions), report-out strategies are relatively simple to devise. With more complex tasks, a little more creativity is sometimes required. For example, if students are asked to create a ranked list, a simultaneous report can begin by asking teams to show (on a card, for example) their top one or two—or bottom one or two—choices.

Beyond the 4-S's: Other Principles of Task Design

4S+1: Focus Tasks on Concrete Actions

Too often, we initiate discussions with students by directly referencing abstractions they have read about, such as definitions, systems, principles, taxonomies. A prevailing assumption is that once students master the language of a definition or schema, they will then be able to use those tools in their thinking and decision making. When we begin with abstractions, however, we frequently find that students can mimic understanding by identifying or even reciting formal definitions but may not really grasp the implications of what they are able to recognize—and even repeat accurately.

Students' 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 without necessarily citing them. The economics example above of teaching "elasticity" by means of a question about the price of ice cream is a case in point. The earlier in the process students can be confronted with specific situations, the more quickly they will gain traction with the abstractions.

To illustrate further, let us consider a classic approach in which an instructor asks students to check their understanding using a multiple choice format and bases the task on statements written in language close to that of the textbook.

Original question:

> By what mechanism does dopamine cause behavior to increase or strengthen?
>
> A. Dopamine causes pleasure.
>
> B. Dopamine motivates willingness to work for reinforcement.
>
> C. Dopamine predicts the arrival of a reinforcer.
>
> D. None of the above

A student responding to this question is likely to recognize a correct answer that echoes the language of the reading ("reinforce"), but familiarity with the language does not indicate that students can apply the concept. To do so, the task would need to be more concretely situated:

Revised question:

> Sara finds that she cannot stop eating chocolate. Which of the following explanations is the most credible?
>
> A. It causes Sarah to feel pleasure.
>
> B. It increases Sarah's motivation to seek out and eat chocolate.
>
> C. It creates a sense of anticipation for something good (chocolate).
>
> D. None of the above
>
> (*example supplied by Kristina Spaulding, Psychology, University at Albany*)

Students who can answer this question accurately are likely to have demonstrated an understanding of how dopamine works, because they cannot slide by with simply parroting textbook language.

What we know about the nature of learning is that students gain deeper traction, faster, with course content if their first encounters with it include concrete experiences framed by and informed by the abstractions. As we move through a learning sequence or cycle, tasks may eventually become more abstract, but students need to start with decisions that make real and visible the significance and implications of targeted concepts.

4S+2: Worksheets Are for Individuals; Decisions Are for Teams

In the interests of efficiency, we may be tempted to present a sequence of small tasks all at once. Designing tasks that lead students through a complete thought process is an essential strategy, but giving teams several tasks at the same time on a single handout or a worksheet will lead to behaviors that TBL is specifically designed to prevent (for example, a dominant student taking over or a "divide and conquer" approach).

Teams are effective when their tasks drive them to converge collectively on a single decision. If we really want teams to work through a suite of tasks, we will need to isolate each one as a separate decision, with

simultaneous report at each step of the way. In this case, they should be scaffolded, one upon the other, each leading to decisions with greater complexity and integration of learning.

If the suite of ideas cannot be represented as a sequence of discrete team decisions, consider assigning the earlier parts of the sequence to individuals to work on separately before assigning teams a decision-making task. This approach works well in courses that require students to practice quantitative calculations. Students work through the necessary calculations individually, then convene as a group to make a broader, more conceptual judgment that is based on the collective understanding gained from individual work.

4S+3: Plan the Debrief When You Plan the Task

The design of a task is ultimately only as good as its execution and management. If you have not anticipated what students' responses to the task will be, you may not be ready to debrief their decisions effectively. What if everybody agrees or gets it right? What if everyone gets it wrong? A task that adheres to 4-S design and works well on paper can be completely derailed in the classroom by the unexpected. Having some strategies in mind can help to avoid this problem.

Have a concrete plan for simultaneous report—and make sure not to follow a simultaneous report with a sequential report of each team explaining its answer. Cluster answers during the debrief: "I see that several of you said 'A.' Team 2, what was your reasoning for 'A'? Ok, did any teams have a different reason for answer 'A'? Team 4, you said 'B'; why?" While it is important to bring to the surface the different reasons for why teams arrived at their answers, polling each team in sequence undermines the purpose of simultaneous report. If every team gets the correct or best answer, the debrief of team answers will proceed very differently than a situation where there is a wide variation in answers. An instructor must assess where a deeper analysis of multiple team answers is required and where it is superfluous or repetitive.

Defer the reveal of a correct or best answer, if there is one, until you have debriefed the teams' responses—"as if" all responses are possible. In some cases, you may even want to leave the problem unresolved, so you can send students back into their teams (or back to the texts) to reconsider their thinking via a new question. Once the instructor has stepped in and offered the "correct" answer, meaningful discussion has ended because the expert has spoken. There is an essential difference between asking student teams how they arrived at an answer that might be right, and asking them how they arrived at their answer if they already know it is wrong.

Know where students are likely to struggle with a task, but be flexible when your prediction isn't on target. Out of respect for students, you may have to let them go a ways down the wrong path before you redirect them to more productive territory. As instructors, we are often made uncomfortable by student errors, and we feel responsible for immediately correcting them. However, intervening too early can diminish a team's sense of ownership of their own responses.

4S+4: Logistics and Management Matter

The problems of typical "group-work" are much more likely to arise if students are unclear about what is expected of them. We have found that some basic logistical strategies are useful in keeping teams focused and engaged.

Give clear directions for each task in writing (ideally projected on the classroom screen). If there is to be a series of tasks, show directions for each separate step/sub-task on a separate slide. Keep directions visible while students are working. This serves several purposes: First, writing out each step of the directions in advance forces you to think through the process in which you want students to engage; second, you don't have to remember all the steps in class because they are right in front of you; third, teams are now able to work autonomously (and you don't have to repeat the directions individually to each of them). Students will quickly learn that they, not the instructor, are responsible for keeping their teams on task.

Use time limits—and make them visible. If students feel that a conversation can continue *ad infinitum*, especially with a complex question, they will defer making a decision (and spend a lot of time trying to convince you that they *can't* reach a decision). Requiring teams to produce an answer—publicly—within a given time helps them maintain focus and also sends the message that "we can't" isn't an option. To create an even greater sense of urgency, always allow less time than you think they really need to answer a given question. The energy that is created by a good task can quickly be depleted by lag time when teams finish before time is up. Finally, this is also a strategy for encouraging teams' autonomy and accountability. Rather than depending on you to remind them of how much time remains to complete a task, students learn that they need to track their team's progress and arrive at answers in the given amount of time.

Practice team tasks from day one. There are several good reasons to have students engaging with challenging team tasks from the first day of class, but one of them is to get them accustomed to the level of autonomy and accountability they will be facing in a TBL classroom. For many

students, this is an adjustment, and there will be some growing pains associated with the process. Starting right away with content-driven, meaningful tasks (even before you discuss the syllabus!) will help to demonstrate not only *why* you have structured your course in the ways you have but also *how* students are expected to handle the process. Naïve tasks work especially well on Day One.

4S+5: Use Non-4 S Tasks Sparingly, but Strategically

A key function of 4 S design is building team cohesion. After teams have begun to perform effectively (often around or after the midpoint of a semester), you may find it possible to mix in tasks that ask for a more complex product. You should continue using 4 S tasks frequently to continue team building, but pushing teams to engage in more synthesis/creation tasks may require more flexibility with task design. For this purpose, we propose a few practices that, when teams are already functioning at a high level, can work with some consistency. Note that many of these examples still allow for and suggest using simultaneous report; keep this in mind any time you diverge from a strict 4 S structure. Having the opportunity to compare products across teams remains powerful, even when those products are complex.

Limited Word Task: Teams are asked to distill a complex idea or set of ideas into a single word or limited number of words (1, 2 or 3)

> *Example:* Given the situation described in the case study you just read, use 3 words to summarize the first actions a therapist would need to address in responding to this patient. When prompted, send a team member to the board to write your 3 words.

Single Claim Task: Similar to the single word task, teams are asked to summarize an argument in a single clause sentence/thesis.

> *Example:* Read the paragraph on the handout and, as a team, summarize its primary argument in a single sentence. When prompted, send a team member to the board to write your sentence.

Construct a Thesis: Teams are given a context and asked to take a stance on an issue and construct a thesis statement that they would use to make a written argument.

> *Example:* Using the example of *one* character in the novel, write a thesis statement to defend or refute the following claim: "In James Baldwin's novel *Go Tell it on the Mountain*, the Church is ultimately a positive force in the characters' lives because it provides an empowering community and a place where individuals can express themselves." When prompted, send a team member to the board to write your thesis.

Framing an Argument: Adapted from Bean's (2001) frame paragraph exercise, this is an expansion of the "construct a thesis" exercise where in addition to creating their thesis, teams are asked to identify the sub-arguments they would use to flesh out their argument.

> *Example:* After you have created your thesis statement, list four arguments (in the form of a topic sentence) in support of your thesis statement with at least one specific piece of evidence from the text, with page number, which you would use to support each.

Diagram or Image Task: Teams are asked to distill and represent a complex set of relationships into a single image, diagram, or flow chart, which is drawn on a large sheet of poster paper. Using a pre-established cue, all the posters go up at the same moment for simultaneous report. Debriefing can be traditional (instructor asks teams to explain their representation), or can be adapted to practices where students comment on each other's works (e.g., gallery walk) using stickers or other tools.

> *Example:* Design a flow chart predicting the sequence of physical and mental actions of children solving the following problem. . . .

Reports and Debriefs for Non-4-S Tasks

Tasks with more elaborated products may require some invention when it comes to having teams report and compare their answers. Rather than have students report sequentially, there are other strategies available for reporting that retain the energy and focus of simultaneous reporting. One of these is the technique known as the "Gallery Walk," in which teams write their products on large sheets of paper and attach them to the wall in the manner of an art gallery. Students (either in teams or as individuals) then pass around the room and record their evaluation or comments for each product. Numbers or other mechanisms can be used to rank products

according to various criteria. In this way, the assessments of the products can be reported simultaneously, for example:

- Hold up a card/number for the poster that represents _____ most clearly.
- Hold up a card for the poster that is most/least _____.

Another approach is for students to attach colored stickers to posters according to given criteria. The reporting then follows from identifying the posters with the most stickers of a given color. Other excellent techniques for reporting and assessing complex team tasks, such as "Stacked Transparencies," "Hot Seat," "Best Solution Tournament," can be found in Appendix 2 of Sibley and Ostafichuk's *Teamwork That Works: Guide to Implementing Team-Based Learning* (2013).

Conclusions

Effective task design can be daunting and time-consuming because it requires a new perspective on both student activity and the content of your course. For this reason, it is important to enter TBL with an attitude of exploration and reflection: Tasks that "don't work" are often very valuable as they give you the opportunity to re-consider your goals and your approach. Just as we advocate for creating a classroom atmosphere where students come to recognize the role of errors in the learning process, we believe that instructors must enter their own TBL courses with the expectation that there is room to learn and grow.

Thinking analytically about what you expect a task to accomplish, the kinds of thinking it is seeking to promote, how it is constructed to induce student action, and the responses you expect from students—these are not only crucial to success in the classroom, but are also key to becoming more facile with the process of task design. After you have experimented with different task structures, based on the principles and strategies discussed in this chapter, you will discover what works for your classroom, your students, and your content. Experience will also help you hone your instincts about where modifications will make tasks more successful. Having just a few of these formats under your belt will ultimately make task design more navigable with each successive implementation.

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Assigning Students to Groups for Engineering Design Projects: A Comparison of Five Methods

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I. Introduction

The fact that group learning can enhance education is well established. No less an authority than Albert Einstein[1] argues persuasively for the essentially collaborative nature of human learning. Likewise, Harold Leavitt suggests that all organizations must consider the influence of informal groups on critical processes:

> "The problem is not shall groups exist, but shall groups be planned or not? If not, the individualized organizational garden will sprout groupy weeds all over the place.[2]"

More recently, researchers such as Bruffee[3], and Johnson and Johnson[4] have explored the positive contributions groups can make to education in much greater detail. Porter[5] asserts that to be its best, education must become a team sport. The Harvard Assessment Seminars found particularly strong support for the use of groups in higher education.[6]

How group assignments should be made to optimize student learning is far from clear. Numerous methods of group assignments can be used, ranging from allowing the students to select their own groups to the instructor making the group assignments using a variety of different criteria. This paper presents the results of an investigation into the effectiveness of group performance using five different methods of assigning students to work groups. The investigation took place at the United States Air Force Academy during the Fall semester 1991, and involved a core course taught by the Academy's Department of Civil Engineering, CE 310, "Air Base Design and Performance."

In Civil Engineering 310 students work on course projects in groups. Before this study, there were no standards for assigning students to these groups; it was left to each individual instructor's discretion, wondering if certain methods of selecting groups might be more effective than others.

II. Course Background

CE 310 is a core curriculum requirement for all junior-level cadets at the Academy. The course was designed to progress from a low Perry-level* to a relatively high Perry-level emphasizing team work, communication (oral and written), and basic comprehensive planning tools for the design of Air Bases for the Air Force.

The course is divided into three distinct blocks: (1) The framework for designing much of the base infrastructure...runway, taxiway and apron/pad designs, rigid and flexible pavement designs, as well as utility systems requirements, (2) Base Comprehensive Planning (BCP) and related socio-political and environmental concerns...noise, Air Installation Compatible Use Zones (AICUZ), and encroachment, and (3) air base performance in a combat environment...force beddown, pre-attack planning, and base recovery after attack. Each block culminates in a group project requiring the students' synthesis of all the material covered in that block. The course also has quizzes and examinations in order to test the students' subject knowledge. Overall, 44% of a student's final grade was based on group effort and 56% on individual effort.

For the Fall, 1991 semester, there were 442 students enrolled in 24 sections of CE 310. Within each section students were divided into work groups of approximately four students. Each section had a maximum of 20 students. The course was taught by eight instructors.

III. Experimental Design

Our intention was to test whether grouping students according to ability (as indicated by their incoming GPAs) or curricular interests (technical or nontechnical) affected student performance, attitudes, or efficiencies when compared with allowing students to select their own groups. Each class, or section, was first grouped by interest: the "technical" group were those students majoring in engineering or the basic sciences, and the "nontechnical" group were those students majoring in humanities or the social sciences. A third group was identified, neither technical nor nontechnical, that consisted of students who were meeting the minimum graduation requirements. This group (Bachelor of Science, BS) would fill a technical or nontechnical position based on the specific needs of a section to completely fill all groups. After the class was separated by interest, the individuals were then rank-ordered by GPA. The desired number of students in each group was four. In most cases, each group had four students assigned, however, for classes with less than 20 students, some three-person teams were created.

*For a complete discussion of Perry Level, see: Culver, R.S. and J.T. Hackes. *Perry's Model of Intellectual Development.* Engineering Education: 221-226 (December 1982)

The five methods of group assignments are illustrated in Table 1. Method 1 involves assigning groups heterogeneously/heterogeneously with respect to GPA and Interest, i.e., each group has both technical and nontechnical majors, and the GPAs of all group members are different. Those groups assigned by method 2 (heterogeneous/homogeneous) are comprised of only technical or nontechnical majors and the GPAs of all group members differ. For method 3 (homogeneous/heterogeneous), each group again has both technical and nontechnical majors, but their GPAs are all similar. Method 4 (homogeneous/homogeneous) has groups assigned with either all technical or all nontechnical majors, and all group members have similar GPAs. Method 5 was the control; students selected their own teams.

All groups within a particular section were assigned using the same method. The methods varied among sections. There were five sections for each method of assignment except for method 1 (heterogeneous/ heterogeneous) which only had four. The five groups in each class or section were named Eagle (E), Falcon (F), Ice (I), Maverick (M), and Yankee (Y), and the groups were selected such that each group had similar average GPAs.

The instructors were informed that an experiment was under way; however, they were not informed as to how each of their section's groups were selected. Instructors teaching multiple sections were likely to have different grouping strategies used in each section. The students were not told they were a part of an experiment. Group assignments were accomplished by the principle investigators, and given to the instructors.

Grading of the projects was standardized among instructors by providing detailed guidance to each instructor so as to make the process as objective as possible. In addition, the Course Director (the person responsible for administering the course) spot-checked each instructor's graded projects to ensure all projects were graded similarly.

	Type of Group
Method 1	Heterogeneous GPA Heterogeneous Interest
Method 2	Heterogeneous GPA Homogeneous Interest
Method 3	Homogeneous GPA Heterogeneous Interest
Method 4	Homogeneous GPA Homogeneous Interest
Method 5	Self-Select

Table 1. Methods of Group Assignments

Critique Questions Used for Analysis

0	1	2	3	4	5	6	7	8	9
Strongly Disagree		Disagree		No Opinion Neutral		Agree		Strongly Agree	

CRITERIA:
1. I would like to take more classes from instructors who teach like this one.
2. My instructor provides a positive image of a military professional.
3. This course stimulated me to think about the material outside of class.
4. This course helped me take responsibility for my own learning.
5. I believe this course will be relevant to my future.
6. I expect my grade to reflect my proficiency accurately.
7. I worked harder in this course than I had expected.

INSTRUCTOR:

1. My instructor helped make this course more enjoyable.
2. My instructor helped me to think more critically about the material.
3. My instructor helped increase my knowledge of the subject.

PROJECTS:

1. Assigned projects, exercises and labs were enjoyable.
2. Projects, exercises and labs helped me think more deeply about the material.
3. Projects, exercises and labs increased my knowledge of the subject.

CLASSMATES:

1. My classmates contributed to my enjoyment of the course.
2. My classmates helped me think more deeply about the material.
3. My classmates helped me increase my subject knowledge.

COURSE:

1. Overall, this course was enjoyable.
2. This course helped me develop my thinking skills.
3. This course has increased my knowledge of the subject.

Table 2. Course Critique

IV. Data Reduction

The following information for each student was collected.
1. Name
2. Squadron
3. GPA
4. MPA (Military Performance Average)
5. Major
6. Type group (1,2,3,4,5)
7. Civ Engr 310 Grades
   A. Group only average
   B. Individual effort only average
   C. Overall average
8. Results of students critiques
   A. Criteria
   B. Instructor
   C. Projects
   D. Classmates
   E. Course
9. Time Studies (The amount of time each group spent accomplishing the projects after Block 1-the 1950s Project, and Block 2-the 1990s project)

Items 1-5 and 8 were obtained from the Academy's Registrar, and items 6, 7 and 9 from data collected from the course.

From the data, the following hypotheses were tested:

1. The method of group assignment affects individual and group performance.

2. The method of group assignment affects students' attitudes toward the material, the course, the instructor or their classmates.

3. The method of group assignment affects group efficiency.

Individual grades, group grades, and overall grades were compared across assignment methods. Likewise, student attitudes regarding criteria, instructor, projects, classmates, and the course were compared by analyzing responses to an end of course critique as shown in Table 2. The time required to complete both the 1950s and the 1990s projects were also

compared across groups. A T-test[7] was used to determine if differences from the control (self-select) were statistically significant. An F-test[7] was used to determine if there was evidence that the variations between the control and other groups were not equal. If there was evidence that variations were not equal, an estimated T-statistic[7] was used to determine if differences from the control were statistically significant.

V. Results

The results of this study are summarized in Table 3. The first number for each entry represents the mean value of the parameter. The number directly below the mean represents the sample variance. The asterisks identify parameter values that are statistically (P<0.05)(7) different from the values for the control group (self-select).

GROUP	1	2	3	4	5
Interest GPA	Hetero Hetero	Homog Hetero	Hetero Homog	Homog Homog	Self Select
Individual	81.4	82.4	82.6	82.3	82.3
Grades (%)	0.35	0.23	0.28	0.35	0.34
Group	85.3	87.7*	87.5*	86.7	86.0
Grades (%)	0.28*	0.09*	0.17	0.28*	0.16
Overall	83.1	84.7	84.8	84.3	83.9
Grades (%)	0.19	0.10*	0.16	0.20	0.17
Criteria	6.44*	6.95*	6.77*	6.09	5.77
	2.69	1.94*	1.61*	2.67	3.07
Instructor	6.64*	7.49*	7.42*	6.18	5.58
	3.04*	2.17*	1.37*	3.70	5.10
Projects	5.61	5.64*	5.36	4.93	4.94
	7.06	6.62	6.07	7.68	8.77
Classmates	6.54	6.28	6.67*	6.10	5.93
	2.73*	5.09	2.89*	4.65	5.09
Course	5.40	5.71*	5.60*	5.29	4.74
	4.62	5.56	4.14	4.55	4.63
1950s	37.48	33.22	41.45	47.32*	33.37
Project (hrs)	18.5	13.8	26.7*	18.1	14.4
1990s	55.85	49.59*	57.20	67.32	57.31
Project (hrs)	25.5	15.8	18.5	20.3	16.8

The first number for each entry represents the mean value of the parameter. The number directly below the mean represents the sample variance. The asterisks identify parameter values that are statistically (P<0.05)(7) different from the values for the control group (self-select).

Table 3. Summary of Results

The results of the grade study are shown in Figure 1. Once again, the methods of assignment are as previously defined with method 5, self-select as the control. For grades determined from individual effort, there were no statistically significant differences between the control and any of the other methods. Likewise for the overall total grades. For group grades, though, students grades were significantly higher for methods 2 and 3, while there was no significant difference for methods 1 and 4 compared with the control. Also, from Table 3, it can be seen that method 2 has the lowest variance in grades. The higher grades with lower variance indicates a better, more consistent performance among groups as well as across group members. The significantly higher variations for methods 1 and 4 indicates a larger range of group performance. It may be for method 2 that students of similar interests find it easier to communicate and work with each other. Also, different GPAs may influence group organization with a natural leader (high GPA) and those that are more likely to prefer to be assigned tasks to complete their portion of the project. This may also impact the group and allow it to perform more efficiently and effectively. Nonetheless, it is appropriate to conclude that group selection had only slight effects on graded performance.

The results of the attitudes study are shown in Figure 2. For criteria, responses for methods 1, 2 and 4 are statistically significantly higher than the control, while there was no significant difference for method 3. The same results occurred when considering the responses rating the instructor. The only significant increase in ratings for the projects was for method 2. The only significant increase in responses toward classmates was shown by method 3. The responses for methods 1, 2 and 4 were significantly higher for the overall course rating. Although not all differences were significant, method

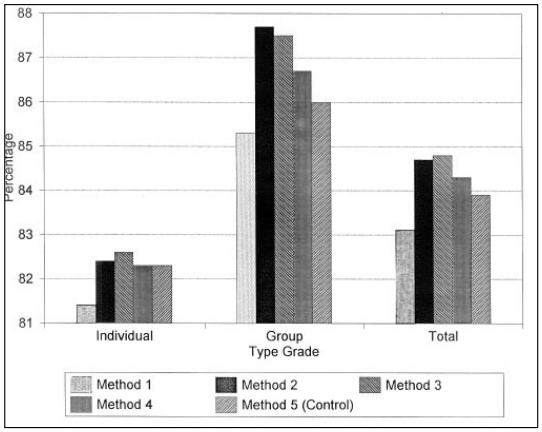

Figure 1.Grade Comparisons Among Methods of Group Assesment

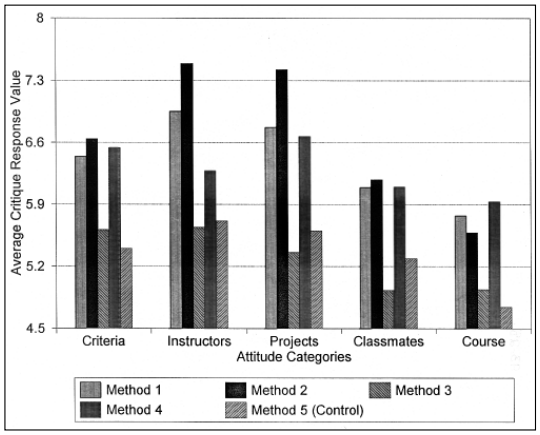

Figure 2. Attitude Comparisons Among Methods of Group Assignment

5, the self-selected control, generally has the lowest ratings of all methods tested across the five categories. In most cases, as seen in Table 3, method 5 also yields the largest variances in responses. It appears that for self-selected groups there is a large range of attitudes about all aspects of the course, with an average rating below that of the other methods of group assignments. No direct measures were taken concerning how students self-selected in method 5, but it is reasonable to assume previous acquaintances and proximity were factors. Thus, self-selected groups may be more "social" entities than other groups. This type of group may actually encourage discontent about all aspects of the course (including the instructor). The results of the Time Study are shown in Figure 3. The only statistically significant differences from the control occurred for method 4 for the 1950s project and for methods 2 and 4 for the 1990s project. Students assigned by method 2 have the least amount of time invested in the projects, while those assigned by method 4 have the greatest amount of time. It is also interesting that most of the four selected groups took a little longer on the first project but then appeared to increase their efficiency during the second project.

VII. Conclusions

1. Appointed groups with a mixture of homogeneity and heterogeneity perform better (earn higher group grades) when compared with self-selected groups.
2. Allowing students to select their own groups results in the poorest attitudes about the course, their instructors, the projects, their classmates, and other criteria.
3. Method 2 of group assignments, heterogeneous with respect to GPA and homogeneous with respect to interest, appears to be the most effective method of group assignment when considering: (1) group performance (group grades), (2) attitudes about the course and its administration, and (3) efficiency in the use of time for this particular course.

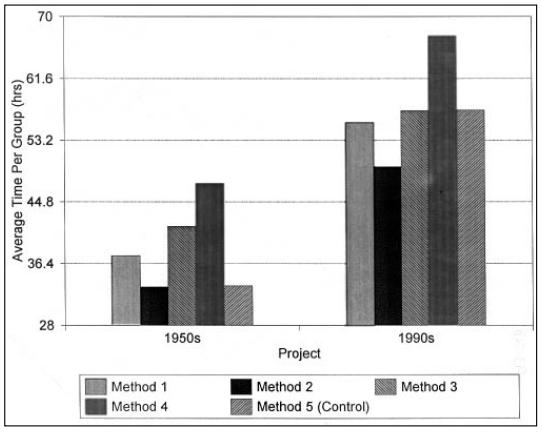

Figure 3. Time Studies Comparisons Among Methods of Group Assignment

Method	1	2	3	4	5
Instructors	A	B	E	H	G
	B	E	D	G	C
	C	F	E	C	C
	D	E	D	G	H
	F	D	A	G	

Table 4. Instuctor Assignments by Method

VIII. Caveats

1. Results may be contingent on the nature/type of group tasks. Generalization to other courses should be done cautiously.
2. The greatest advantage in the attitudes for methods 2 and 3 appears in the instructor category. Since this was a factor that was supposed to be randomized across methods, it might reflect a nonrandom distribution of instructors. A review of the instructor assignments resulted in the distribution shown in Table 4

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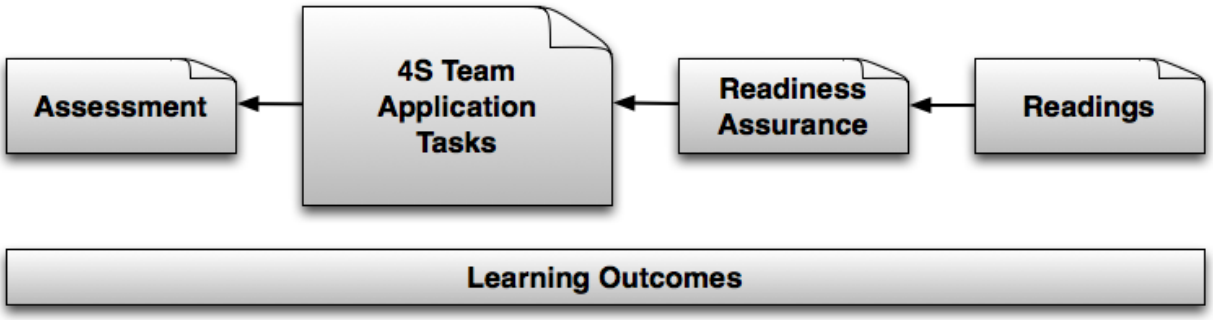
Building your first TBL Module

Homework Assignment



Part One: Design a TBL Module

Your task is to design one TBL module (backwards of course!). Use the following questions to guide your effort.

1. Define Module Learning Outcomes

W*hat will your students will be newly able to do as a result of this module and its activities?*

Your answer to this question will be your module learning outcomes.

Write 2-3 outcomes as concrete actions, for example:

- In a political science course, you might want students to become effective at ***analyzing*** *and* ***assessing*** the factors that contribute to political corruption.
- In a construction management course, you might want students to become skilled at **interpreting** drawings, or **analyzing** a project plan for budgetary purposes.
- In a geology class, you might want students to be able to ***infer*** from specific geological landscapes the ***probable causes*** and history of their formation.

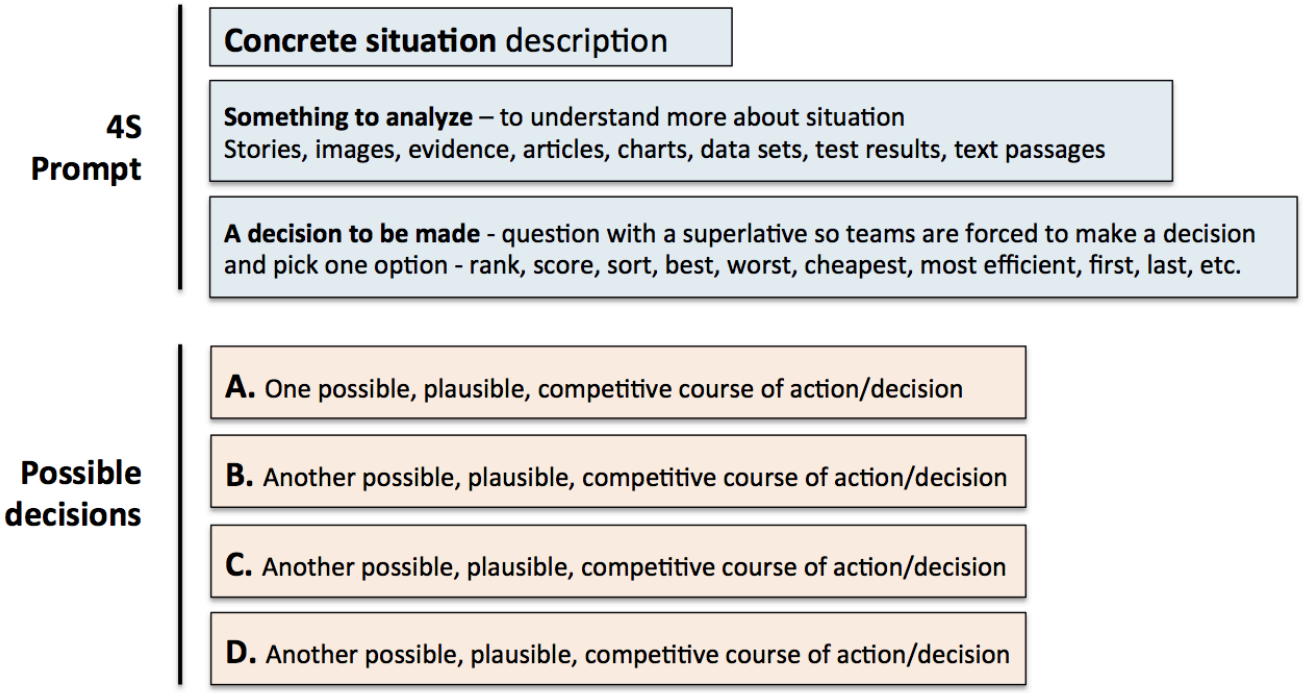
Support Resources: Writing Learning Outcomes and Bloom's Taxonomy sections of *Creating a TBL Module Thread*, TBL book p. 18, 116-118

2. Identify Content that will be used in Module

Make a list of the concepts, ideas, principles, perspectives, core facts, and other information that students need in order to be ready to accomplish the learning outcomes. These are normally things that would be covered in the reading assignment.

3. Build 4S Activities

Now it is time to take those concrete actions described in the learning outcomes and turn them into 4S task/activities. You want to design a sequence of **in-class 4-S tasks** (at least 3) that your students will do in order to get some practice thinking in this new way and developing their analysis and judgment skills. You might want to scaffold the tasks from simple to more complex. Make sure these are challenging and require more than simple recall of "correct" information. It's OK if there's a best or "correct" answer, as long as there's enough ambiguity, complexity and doubt for deep discussion.

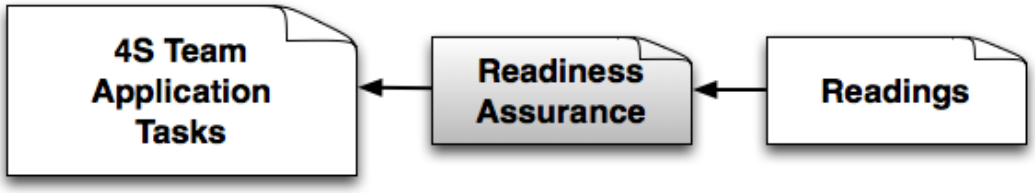


For each activity, create you will need to step-by-step instructions that highlight what students will need to do to complete the task. Write down the ***actual instructions*** and ***prompt/question*** you will use to direct students through the task.

Support Resources: *Creating a TBL Module Thread*, TBL book p.114-142, 186-196

4. Create Readiness Assurance Test

The Learning Outcomes and 4S tasks create the major shape for the module. Now it is time to identify more specifically what students will need to read (or watch, if you use videos) in order to acquire the resources and tools (information!) needed to begin participating in the activities you have designed. What are the (best) chapters, articles, pages, clips, etc. that convey the targeted ideas? Make a list of these items, which you will eventually give to students as their reading assignment.



How much is appropriate varies, but keep in mind that you want students to read for basic awareness and understanding, not mastery. The reading needs to be rich enough and long enough to provide starting content for several activities over the length of the module.

Now **write 5-10 multiple-choice questions**, based on the reading, that focus on your target content. Like the readings, the test is about first exposures and ensuring readiness, not mastery.

- Create some questions at the level of recall and understanding
- Create some questions at the level of application and analysis (comparison, contrast, for example)
- Create a few items that are likely to generate some debate and discussion

Supporting Resources: Writing multiple choice questions and Bloom's Taxonomy sections of *Creating a TBL Module Thread*, TBL book p. 74-113

5. CONSIDER HOW YOU WILL EVALUATE THE LEARNING

How will you know what the students can do at the end of a module and if they have achieved the learning outcomes?

There are many possibilities (select at least one for this assignment):

- Individual assignments
- Traditional individual testing – quiz, midterm, final examinations
- Team analysis worksheets completed as part of 4S task

If you want to use an assignment, write down the actual assignment prompt.

If you are using testing, write down 2-3 of the actual higher-level questions that you will use for your final evaluation.

If you are going to have teams complete a worksheet that highlights their analysis, write down the prompts you will use to instruct students on what you want them to do and record.

Part Two - Prepare a micro-summary of your module

You will use this summary to present your work with your colleagues and get feedback.

- 1-page version of the module (ONE SIDE of ONE SHEET)
- Teammates will read this as a way of getting a picture of what your plans are.
- **Please bring 5 copies of this 1-pager.** Email Jim Sibley (jim.sibley@ubc.ca) by 7 am Thursday morning if you want copies printed for you.

Your Micro-Summary should include:

1. A few action oriented **learning outcomes**
2. List of 2-3 key concepts, ideas or other critical information that students will need to get from the **readings** and a description of the reading/prep assignment (sources)
3. One **RAT** question
4. One in-class **4-S activity –** be prepared to point out where each of the 4S's is present in the activity.
5. Description of **final assessment** strategy
6. Any other concern or issue that you would feedback on.

Creating a TBL module thread

When we first try to envision a TBL module, it can be helpful to imagine the module, as a tapestry of learning. Our first task is to create the threads that the tapestry will ultimately be woven from. A single thread will link a Learning Outcome, to a 4S activity, to Readiness Assurance questions, finally to a reading.

The Learning Outcomes defines where we want student to go, the careful combination of a reading and Readiness Assurance questions get students ready to apply what they abstractly know, and the powerful 4S learning tasks then lets students put their knowledge to work in the concrete world and show us they know.

We design backwards - first by defining the desired Learning Outcomes, then turning our attention to the creation of a 4S task, and finally selecting the readings and creating the Readiness Assurance questions to ready the learners.

Step 1-3: Create Learning Outcome

Step 1: Create a Learning Outcome

Define Flood Return Period

This is a very typical content focused, low Bloom's level learning outcome.

Step 2: Raise the Bloom's level of Learning Outcome

Explain Flood Return Period

In this step, we raise the Bloom's level. See page 6 of this section for different verbs you can substitute to target higher Bloom's levels. In this example, the change has moved the learning outcome from the lowest Bloom's level – *Remember* - to the slightly higher *Understand* level.

Step 3: Make Learning Outcome about Action

Demonstrate understanding of Flood Return Period

In this step, we change the learning outcome to be about concrete action rather than abstract understanding.

But in this example selecting a verb like "demonstrate", doesn't provide any information on how the students might "demonstrate understanding". It is time to think about how to make student thinking more visible. We do this by imaging a 4S task that will give students the opportunity to use what they know, extend their knowledge, and finally show us they know (achieve Learning Outcome).

We now want to think about our discipline and the kinds of questions experts are routinely asked to make, the kinds of data they work with, the inferences, judgments, and decision

they are required to make. These will ultimately be the source of your inspiration of what makes a great 4S task.

Step 4-5: Design 4S Team Tasks

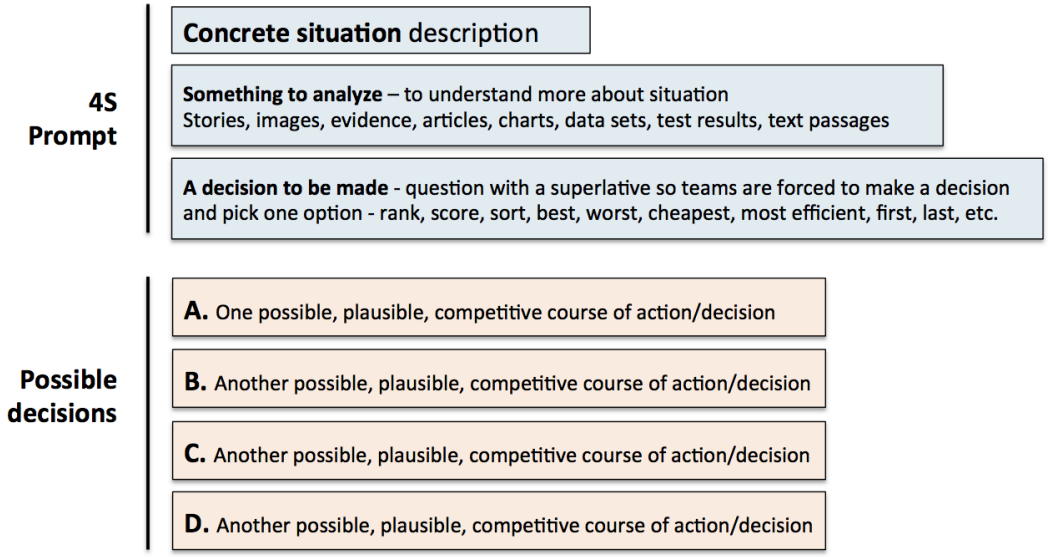
Step 4: Select a 4S question prompt

It is worth remembering we want the question prompt to constrain the decision space, so the reporting discussion is more focused on salient issues. Think about the difference that would occur when we imagine the report conversation for **what would be the best thing to do in this situation** versus the more diffuse **what would you do it this situation**?

Combining the identified disciplinary action with the desired Learning Outcome, it is time to go shopping for a 4S question prompt. You want one that contains a superlative (like **best** above) that will make students analyze, discriminate, and finally report a reasonable choice or course of action. See page 14 of this section for a list of possible 4S prompts.

Step 5: Use template to create 4S question parts

Once we have a question prompt in mind, we can start completing the other pieces of a complete 4S question. It is worth noting that the specific detail you add to the scenario can guide students to analyze the problem a certain way using the provided detail or pointers to data sets. Similarly, the mix of different course of action/decisions possibilities can have students naturally examine the situation from a specific set of perspectives that you have intentionally pointed them towards.



Step 6-8: Design Readiness Assurance Sequence

Step 6: Determine important concepts to test

Looking at the 4S task you have created, it is time to think about what concepts, definitions, and vocabulary the students will need to start their analysis. Make a preliminary list.

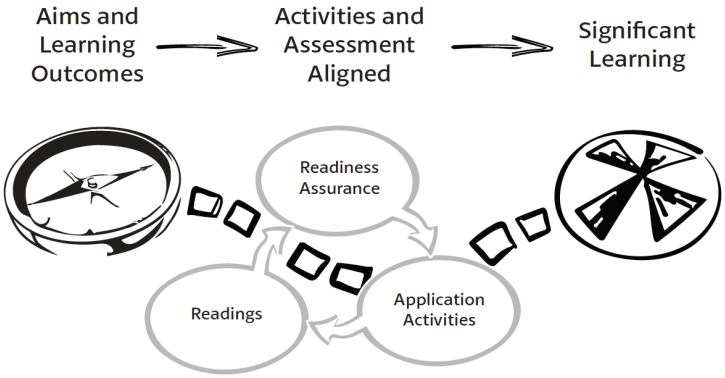
Step 7: Select Appropriate Reading

Knowing what concepts, definitions, and vocabulary your students need to get started – find a concise reading that has sufficient detail (not too much) and is at an appropriate reading level to be accessible to your students.

Step 8: Create a variety of Readiness Assurance questions

Time to write a few multiple-choice questions for the Readiness Assurance test. Question should be a mix at mostly Bloom's levels – remember, know, and some light application. See the Bloom's section page 6 of this section for suggestions of possible question leaders. Select a few leaders and complete your multiple-choice questions.

Creating Learning Outcomes



BUILD YOUR FIRST SIMPLE LEARNING OUTCOME

Creating great learning outcomes is a cyclic, iterative process where you revisit and refine as your course design proceeds. You create your first provisional outcomes are then used to build other components of course design – selecting teaching and learning activities and designing assessment materials. As the other components begin to come into focus, you will periodically revisit and refine your initial learning outcomes. At a very simple view – writing a learning outcome can be as simple as attaching a Bloom's verb to a piece of a piece of content.

Consider: I want students to know about flood return periods, I could simply add the Bloom's verb "describe" to flood return period.

Describe + *Flood Return Period* = Learning Outcome

Learning Outcomes are directly focused on student achievement and become more detailed by module end, on exactly what the students will be able to do. Learning Outcomes often contain references to the knowledge, skills, and judgment abilities you want your students to develop. Your initial Learning Outcome statements are often the precursors to ideas for 4S Application tasks.

Learning Outcomes are often much more rigorously constructed then this simple approach. A model known as the ABCD model is often applied.

A – stands for audience – "The student will"
B - stands for behaviour – "write an explanation"
C – stands for condition – "in 30 minutes"
D – stands for degree – "with no mistakes"

For our purpose we can keep the learning outcomes simpler at the beginning.

How to make Learning Outcomes that are good for TBL

When we start thinking about the 4S Application tasks, we want to try to write Learning Outcomes that focus on more concrete actions rather than abstract understanding. We are looking for concrete actions just like a discipline expert takes. Good Learning Outcomes express how experts in your field or discipline would use the course content to solve disciplinary problems. The more concrete you can make the learning outcomes the easier it will be to develop 4S Application tasks from them.

Sample Learning Outcomes for a statistic course: by the end of this course students will be able to use their knowledge of statistical principles to:

- Complete a statistical analysis
- Select an appropriate sampling plan
- Develop a survey instrument and plan to gather information from a specific population

Sample Learning Outcomes for a genetics counseling course: by the end of this course students will be able to use their knowledge of genomics to:

- Interpret genome sequencing data
- Identify genetic markers with greatest risk of disease/abnormality
- Develop counseling plan to work with specific family issues

Sample Learning Outcomes for a business course: by the end of this course students will be able to use their knowledge of marketing principles to…

- Conduct a market analyses
- Evaluate a marketing plan
- Select or Develop marketing techniques to reach specific populations of clients

Sample Learning Outcomes for a history course: by the end of this course students will be able to use their knowledge of early Canadian history to…

- Interpret written accounts of historical events in light of cultural dynamics
- Assess (and estimate) the bias or orientation of a given author
- Develop arguments for current policies or political positions based on historical context

Bloom's Taxonomy

Benjamin Bloom helped develop the **Cognitive domain** taxonomy of educational objectives to help educators prepare examinations and other assessment materials that test different levels of knowledge .and understanding.

Bloom's can be effectively used to create test items that test different levels of understanding, since the different levels can directly be mapped to specific verbs. These verbs can both be used to generate learning objectives and create test questions that correspond to Bloom's different levels.

Blooms – Cognitive Domain
Remembering
Understanding
Applying
Analyzing
Evaluating
Creating

COGNITIVE DOMAIN (LOWER LEVELS)

REMEMBERING

Verbs: Recalling, defining, recognizing, listing, describing, retrieving, naming

Common Question Leaders:

- What is the definition of….
- What is the name of…
- What is the best description of…
- List the following….
- Why did….?
- How is…?
- Where is…?
- When did … happen?

Understanding

Verbs: Explaining ideas or concepts, interpreting, summarizing, paraphrasing, classifying, explaining, locating, identifying, restating

- **Common Question Leaders:**

- How would you classify…?
- What facts or ideas best shows….?
- Interpret in your own words…?
- Which statement best supports…?

- How would you summarize…?
- What is the main idea of…?

Applying

Verbs: implementing, carrying out, using, *executing, translate, employing, illustrating*

Common Question Leaders:

- What is the best first step?
- What is the most significant problem?
- What would be the worst thing to do?
- Would it be a mistake to…?
- What is the most common mistake?
- Which test would you order next?
- What is the most common diagnosis?
- How would you use…?
- How would you solve?
- What is the most logical order?
- What approach would you use..?
- What would result if….?
- What facts would you select to show…?

SOME TIPS FOR USING BLOOM'S FOR TBL

Write a variety of Low-level questions

- What did the text say? (Remembering)
- What did the text mean? (Understanding)
- How could you apply it? (Recognize an example of a concept)

Have a few Low-level questions that invite discussion

- Which statement is most accurate?
- Based on the theory that you read about, what is most likely to happen is we apply X?
- Which of these items best represent the qualities/characteristics of X?

Have one or two Higher-level questions that invite discussion

- Based on what you have read about theory A, which of the strategies listed below has the best chance of success, given the specified conditions (X, Y, Z)?

Illustrative knowledge questions

Knowledge of Terminology

- What word means the same as _____?
- Which statement best defines the term _____?
- In this sentence, what is the meaning of the word _____?

Knowledge of Specific Facts

- Where would you find _____?
- Who first discovered _____?
- What is the name of _____?

Knowledge of Conventions

- What is the correct form for _____?
- Which statement indicates correct usage of _____?
- Which of the following rules applies to _____?

Knowledge of Trends and Sequences

- Which of the following best describes the trend of _____?
- Which is the most important cause of _____?
- Which of the following indicates the proper order of _____?

Knowledge of Classifications and Categories

- What are the main types of _____?
- What are the major classifications of _____?
- What are the characteristics of _____?

Knowledge of Criteria

- Which of the following is a criterion for judging _____?
- What is the most important criterion for selecting _____?
- What criteria are used to classify _____?

Knowledge of Methodology

- What method is used for _____?
- What is the best way to _____?
- What would be the first step in making _____?

Knowledge of Principles and Generalizations

- Which statement best expresses the principle of _____?
- Which statement best summarizes the belief that _____?
- Which of the following principles best explains _____?

Knowledge of Theories and Structures

- Which statement is most consistent with the theory of _____?
- Which of the following best describes the structure of _____?
- What evidence best supports the theory of _____?

Illustrative comprehension and application questions

Comprehension Questions

- Which of the following is an example of _____?
- What is the main thought expressed by _____?
- What are the main differences between _____?
- What are the common characteristics of _____?
- Which of the following is another form of _____?
- Which of the following best explains _____?
- Which of the following best summarizes _____?
- Which of the following best illustrates _____?
- What do you predict would happen if _____?
- What trend do you predict in _____?

Application Questions

- Which of the following methods is best for _____?
- What steps should be followed in applying _____?
- Which situation would require the use of _____?
- Which principle would be best for solving _____?
- What procedure is best for improving _____?
- What procedure is best for constructing _____?
- What procedure is best for correcting _____?
- Which of the following is the best plan for _____?
- Which of the following provides the proper sequence for _____?
- What is the most probable effect of _____?

From: *How to make Achievement Tests and Assessments* - 5th edition by Norman Gronlund

Writing RAP Questions

At the heart of the Readiness Assurance Process is a series of readings and multiple-choice tests that cover the important fundamental knowledge that students will need to know to begin the 4S application activities.

GETTING READY TO WRITE RAP QUESTIONS

Once you understand what the culminating student performance will be, you turn your attention to preparing student for first engagement with the content (reading and RAP) and then the progression of 4S activities that leads to that culminating 4S performance.

Identify specific knowledge the students will need to begin effectively engaging with the 4S activities. This is not everything they need to solve every activity but what they require as an entry point to the problem-solving conversation. You do this by mapping back from the 4S application activity to important foundational knowledge that the students will need to be successful. When you are clear on the basic knowledge students need to know, you are then ready to select appropriate student preparation materials and construct RAP questions.

Select appropriate student preparation materials. There is an iterative loop as you select/define/refine the concepts to be initially tested, and then select and refine the preparation materials. For preparation materials, we most often use readings, but videos, lecture recordings, or narrated PowerPoint's can work well. Over the years we have discovered that less is more with readings. The amount of readings that students will tolerate depends on the particular discipline and institutional context. Our readings are closer to 25 pages for 2 weeks, which is down from our original 75 pages for two weeks. We found that students were spending a short, fixed amount of time completing readings without regard for complexity and length of readings. Remember the Readiness Assurance Process is not trying to be comprehensive. It is just giving students an entry point to the problem-solving conversation.

One aside – when teachers are first introduced to the idea of the flipped classroom, they are often concerned on how to cram their 1 hour lectures into a 10-12 minute videos. This is the wrong way to look at it. The preparation materials are just to get students started. It is not all that students learn in a module, so you need to create a selective subset of your 1 hour of lecture content – focusing of high level themes and must know basic concepts and definitions. Students will be motivated to learn the additional content to solve the exciting 4S team tasks.

Develop a list of important concepts and ideas to test with your RAP questions. The RAP question coverage doesn't need to be comprehensive, you are providing students the foundational knowledge and understanding they need to begin problem-solving.

WRITING MCQ QUESTIONS

Multiple-Choice questions have two main parts: the question stem or leader, and the options (which include a correct answer). When beginning to construct a multiple-choice question, write the stem of the question first. A well-constructed stem is a stand-alone question that could be answered without examining the options. The wording of the stem and the verbs it contains determines the overall difficulty of the question.

Multiple-Choice Questions have a reputation for only testing lower level skills like knowledge and recall. In the question example below students are asked the difficult task - *to select the citation that is most accurate*. All citations have errors and the students are really being asked to "hypothesize" which errors will have the greatest impact on the citations effectiveness. This question is testing at a very high "Blooms" level. Writing questions at higher "Blooms" level is difficult, but NOT impossible.

In your argument, you are citing a number of cases from different courts. This is the first time you cite any of these cases. What is the most accurate citation sentence (use your citation manual)?

1. *Wyman v. Newhouse*, 93 F.2d 313, 315 (2d Cir. 1937); *Henkel Co. v. Degremont*, 136 F.R.D. 88, 94 (E.D. Pa. 1991), *Willametz v. Susi*, 54. F.R.D. 363, 465 (D. Mass. 1972).

2. *Henkel Co. v. Degremont*, 136 F.R.D. 88, 94 (E.D. Pa. 1991); *Willametz v. Susi*, 54. F.R.D. 363, 465 (D. Mass. 1972); *Wyman v. Newhouse*, 93 F.2d 313, 315 (2d Cir. 1937).

3. *Willametz v. Susi*, 54. F.R.D. 363, 465 (D. Mass. 1972); *Henkel Co. v. Degremont*, 136 F.R.D. 88, 94 (E.D. Pa. 1991); *Wyman v. Newhouse*, 93 F.2d 313, 315 (2d Cir. 1937).

4. *Wyman v. Newhouse*, 93 F.2d 313, 315 (2d Cir. 1937), *Willametz v. Susi*, 54. F.R.D. 363, 465 (D. Mass. 1972), *Henkel Co. v. Degremont*, 136 F.R.D. 88, 94 (E.D. Pa. 1991).

Have a peer or colleague review your questions. It can be difficult to see flaws in our own questions, when we have spent hours writing them. A fresh set of eyes can help us catch many errors. There is nothing more uncomfortable then dashing off a set of poorly written questions, rushing to class, and enduring the inevitable student backlash and discontent.

SOME RULES FOR MCQ QUESTION WRITING

For good question stems, consider following rules:

- Stems should be stand-alone questions.
- Stems should be grammatically complete.
- Negative stems should be used with caution.
- If a key word appears consistently in the options, try to move it to the stem.
- Word the stem such that one option is indisputably correct.

For creating good options, consider following rules:

- Make sure each incorrect option is plausible but clearly incorrect.
- Make sure that the correct answer (keyed response) is clearly the best.
- Avoid, if possible, using "all of the above".
- Use "none of the above" with caution.
- Try to keep options similar lengths, since test-wise students will pick the longest option if unsure (too long to be wrong).
- Make sure options are grammatically consistent with the stem (question leader) and use parallelism.
- Make sure that numerical answers are placed in numerical order, either ascending or descending.

Well-constructed multiple-choice questions are not easy to create. But the quality of the multiple-choice questions you use in your Team Test can make or break the tone of your class. Nothing is more uncomfortable than rushing poor questions to the classroom and having to endure the inevitable student backlash. Good questions are absolutely essential to our success, and putting in the effort to write good questions is worth your time and attention.

Spend time reviewing and revising your questions. It can be very helpful to have a colleague look at your questions. When we write them we are often too close to see all the mistakes. Just like good writing is about good editing, good MCQ questions are about reflection and revision

QUESTION LEVEL MIX ON RAP TESTS

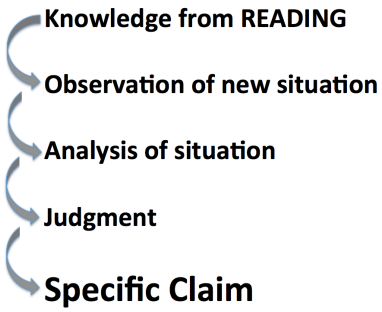
Write your RAP multiple-choice questions at Bloom's Remember, Understand, and light Application level of difficulty. This is not about testing all that students will learn in the module, but instead only what they need to begin effectively problem-solving (4S Application Activities). It is important to pitch the RAT at the right level to encourage students to engage deeply but not so difficult that they lose heart.

The test should be a mix of approximately 20% remembering (did you do the readings?), approximately 60% understanding (did you understand what you read?), and finally, 20% application, The application questions can be in the form of "which concept applies to this situation" (are you ready to use what you have read?). To use a book analogy, you want to write these tests more at the table-of-contents level then at the index level.

You can include a few simpler questions that just provide simple accountability that the student has completed the readings. Try to ask about topics that students are likely to interpret incorrectly. Test common misconceptions that might undermine students' ability to successfully begin problem-solving. You can ask which concept applies to a given situation or scenario. You can focus on the relationship between concepts; this is an efficient way to test two concepts at once.

Designing 4S Tasks

During a 4S Application task, students get to concretely apply what they have abstractly learned from the readings. You want students connecting abstract concepts from the readings with concrete experience during the 4S team Application tasks. Making connections during 4S team tasks is important to consolidate student learning.



Helping students see gaps in their knowledge motivates the students' look up what they don't know and then immediately putting that knowledge into action tests and deepens their understanding.

You need to present a scenario that creates the context in which what students "know" abstractly (via their readings) is put to the test when they try to "use" it in concrete, specific case. Your job is to find or, if necessary, fabricate these scenarios.

4S Extended Example (from Roberson)

> *Students in Sociology might "know" Maslow's hierarchy of human needs, and could score well on a test that asked them to recite and explain it. But now imagine the Application task you give students, based on their initial understanding of Maslow:*
>
> *You are a social worker and you have been given the case of "Maria from Syria." Given your understanding of Maslow's hierarchy, look at these data, make an assessment of her situation, and decide the best way to proceed in interacting with her: "Maria comes from a middle class family (her father was a dentist) in a small town in war-torn Syria. She immigrated with just her two children to Canada 2 years ago, and came to Ontario. She now works long hours at minimum wage as a housekeeper. She recently re-married and currently lives with her abusive, alcoholic husband. One of her children has health problems...etc."*
>
> *If the details of the case are rich, it quickly becomes clear to students that Maria's case is complicated, and that Maslow's hierarchy, while it is a useful tool to help analyze the situation, does not lead to an easy assessment or judgment.*

Example 4S prompts (superlatives or implied superlatives to force a specific choice)

- A patient comes into emergency with the following symptoms...
    - What is the **first** thing you would do? And why?
    - What is the **first** test you would order? And why?
    - What would be the **worst** thing to do? And why?

- Given 3 possible programs to end homelessness in your city, select the program that is the **best** and will likely be most strongly supported by local agencies and Civic leaders? (Michaelsen and Sweet)

- What is the **most** relevant theory that explains the behaviour in the video? (Kubitz and Lightner)

- Which of the following **best** describes the opportunity cost of coming to class today? (Espey)

- Which of the following should the University do to **best** increase the quality of Undergraduate education? (Mahler)

- Which sampling scenario would **best** address this research project? (Mahler)

- Given three valid historical interpretations of the progressive Movement, discern which **best** describes the Progressives revealed in our manifesto? (Restad)

- In Clarence Page's op-ed piece "The Problem With Trashing Liberty"' where does the responsibility for a safe a civil society lie? Which of the following three philosophers (X, Y, and Z) does Clarence Page **most** agree with on these fronts? (Roberson and Reimers)

- What of the following passage in the Bhagavad Gita **best** illustrates reflection about the nature of Krishna's divinity? (Dubois)

- Rank how useful each source is for understanding the fears of the Cold War era. (Restad)

- Which teacher should be nominated for a teaching award? (Croyle and Alfaro)

- Which indicator (from a list of 5 plausible alternatives) is **most** critical to making a correct diagnosis in this case? (Michaelsen and Sweet)

- If a moving vehicle overloaded this bridge structure, which component would likely fail **first**?

- You are making a home assessment, which of the following safety hazards would be of **greatest** concern? (Clark)

- After assessing Mrs. Randall's dining room what would be your **first** recommendation to protect her from falls? (Clark)

- What line on this tax form would pose the **greatest** finical risk due to an IRS audit? (Michaelsen and Sweet)

- Given a set of real data, which of the following advertising claims is **least** (or **most**) supportable? (Michaelsen and Sweet)

- You are consulting for a new business owner who wants to open a dry-cleaning store in Norman, Oklahoma. Where would you recommend locating a new dry-cleaning business? (Michaelsen)

ANOTHER PATHWAY DESCRIPTION OF 4S DEVELOPMENT PROCESS

First, you may need to make your original Learning Outcomes more CONCRETE.

Next, you need to create problem scenarios/situations where students' factual knowledge (*from RAP process)* is useful, but maybe insufficient to solve the problem definitively.

Next, when creating these scenarios you want to clarify exactly what do you want students to be doing.

- Evaluate/judge something (object, product, creation, situation)?
- Analyze or diagnose a situation?
- Interpret something (text, artifact, data set)?
- Solve a particular type of messy problem?

Next, identify the concrete information/data sets the students will work with:

- Texts (such as cases, descriptions, excerpts from a textbook, writing samples, etc.)
- Images (visualizations, diagrams, videos, etc.)
- Data (spreadsheets, graphs, charts, etc.)
- Objects (products, specimens, etc.)

Next, you need to pick the format of students' action:

- Will they compare?
- Will they sort?
- Will they rank?
- Will they score?
- Will they choose the best course of action?
- Will they distill and represent in a written format?

Next, determine how to make student thinking/decisions visible so it can be represented in a simultaneous report. Can their answer be represented with?

a. Colour Voting Cards
b. Single Number
c. Single Letter
d. Single word or phrase

Sometimes this means converting a complex response into a simple response. For example, after a ranking task, ask students to report their #1 choice, rather than their entire ranking scheme. If you've asked students to compile a list, ask them to choose the MOST critical item on their list and report it. Every task needs to lead to a moment of sharp differentiation: "I choose this over that." Getting the students to this moment sets up "WHY?" as the teacher's entry point for interactions leading to student analysis, reflection, and critical thinking. The simultaneous report naturally lets teams compare their decisions and decision-making process to other teams.

Finally, it is good to develop a facilitation plan for debriefing the 4S Application task, to ensure students learn the most they can from the task. Debriefs always begins by asking ALL teams to simultaneously report their answers/decisions. A good plan provides you with a way to organize the discussion that follows, and direct students into a dialogue with each other.

Instructor: "OK, I see three groups said "B" and two groups said "C." Let's start with those of you who said "C." Please explain to the other students why you chose this answer?

Later: OK, teams who said B, how would you respond to them?

Later still: Nobody chose A. Why did you discount that possibility?

Learning Outcome to 4S Activity Story

Define Flood Return Period

This is a very typical content focused, low Bloom's level learning outcome. Next step is to raise the Bloom's level (in this case using Bloom's Cognitive Domain Taxonomy).

Explain Flood Return Period

The change has moved the learning outcome from the lowest Bloom's level – Remember - to the slightly higher - Understand – level. In the next step, we try to change this learning outcome to be about concrete action rather than just abstract understanding.

Demonstrate understanding of Flood Return Period

This is often the first attempt at making the learning outcome more about concrete action. Unfortunately, it doesn't provide any information on how the students might "demonstrate understanding". In the next step, we try again to make it about concrete action but this time so student understanding is put to use in a visible way.

Students will predict the outcome of a situation

This is getting better. Students are using their knowledge of Flood Return Period and applying abstractly to a concrete situation. This is key. You can start to get glimmers of what an activity might look like where students show you that they know (knowledge in the service of action). But what is missing here is discrimination and judgment.

Students will predict the most likely outcome of a specific situation

We now have discrimination and judgment but still a little too open ended to have students make decisions that are easily comparable and drive an intense reporting discussion that examines only the salient issues that need to be considered to make a "good" judgment and decision "in this case". Constraining the possible outcomes to be considered can help you structure the analysis and discussion so very specific issues are discussed and very specific analysis is done. Lets constrain the possible choices!

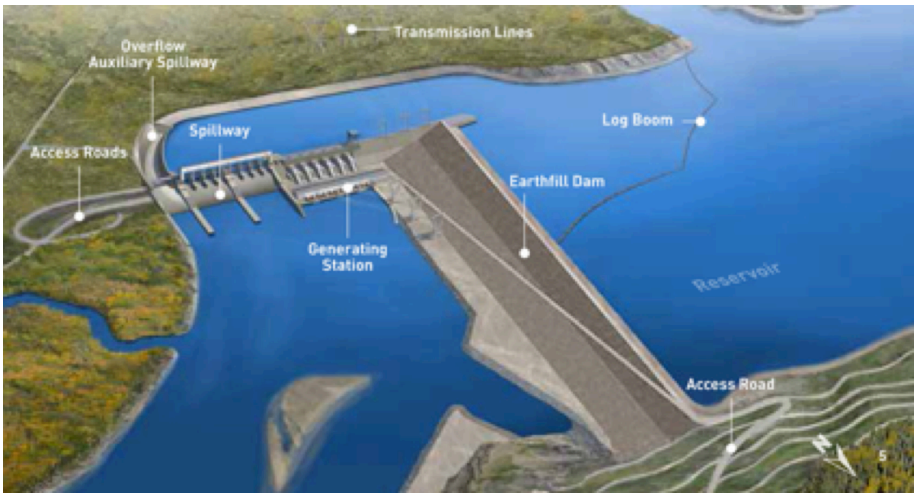
FINAL TRANSFORMATION TO 4S ACTIVITY

Which of these outcomes is most likely given this situation (using your knowledge of flood return period)

- **Possible Outcome 1**
- **Possible Outcome 2**
- **Possible Outcome 3**
- **Possible Outcome 4**

We have transformed a lower level learning outcome, that at best could be assessed in an examination, into a powerful classroom activity that is structured to lead to a rich, deep reporting discussion.

FINAL ELABOARTED VERSION OF THIS 4S ACTIVITY



You are head of Engineering for a large dam project on the Yellow river in the Ningxai province of China. The dam is to be located in the Yiling district near the exit of the Ordos Loop section of the river. The dam is to be located at 34°49′46″N 111°20′41″E. The Yellow river is China's third largest river. The river is characterized by extremely high silt loads, especially in spring floods. The local bedrock is highly fractured gneiss. The dam will be a concrete earthfill hybrid design. You have been asked to determine some of the main design parameters, including safety related question like what flood event return period to build the dam to withstand.

What **flood return period** would you recommend the dam be designed to withstand?

A) once in 50 year flood
B) once in 100 year flood
C) once in 200 year flood
D) once in 500 year flood

USING THE 4S STRUCTURE

Lets examine how to structure problems using the 4S framework so they lead to consistently powerful activities. There are 4 major tenets to consider when structuring a 4S activity.

First, we should use the kinds of questions/problems and problem solving/analysis procedures that **disciplinary experts** are routinely asked to use/make. Since most disciplines are more about their actions rather than there content. Next we need to make problem about **concrete action** in a concrete situation with real consequences. This helps make student understanding visible to both the teacher and student. Then we need to think about the kinds of **complex analysis** that will required of students to analyze/interpret the scenario or problem statement. Finally, we will need to **constrain choice** to intensify the learning.

TENET 1: USE EXPERT-LIKE DISCIPLINARY PROBLEMS

A nice feature of this example is that it asks the kind of question an expert would need to make.

"Disciplines are more clearly defined by how those working within the discipline collect, organize, assess, and use information" (Roberson and Franchini, 2014, p. 278)

"If we want our students to become more expert in our disciplines, we need to structure their encounters with content in ways that change what they can do with knowledge." (Roberson and Franchini, 2014, p. 278)

TENET 2: MAKE IT ABOUT CONCRETE ACTION IN THE REAL WORLD

Students need to use their understanding (gained in the pre-readings, lectures or previous activities) to make expert-like concrete decisions that will have very concrete consequences. You want to design concrete scenarios where conceptual and abstract understanding helps students make better decisions.

The quality of the problem ultimately controls the effectiveness, energy, and learning outcomes of an activity.

"Students, therefore, need to be required to act frequently in ways that generate consequences that provoke reflection and demonstrate visibly their thinking. The more focused and concrete the action, the more visible will be the thinking and the learning—and the more immediately useful will be the feedback." (Roberson and Franchini, 2014, p. 276)

"Effective team tasks point students consistently toward making decisions that reveal reasoning and understanding in service of a judgment." (Roberson and Franchini, 2014, p. 279)

"What we know about the nature of learning is that students gain deeper traction, faster, with course content if their first encounters with it include concrete experiences framed by and informed by the abstractions" (Roberson and Franchini, 2014, p. 296)

TENET 3: REQUIRE COMPLEX ANALYSIS, DISCRIMINATION, AND JUDGEMENT

Coming up with a good and defensible solution requires the integration and analysis of many different factors and the weighing of tradeoffs (like cost vs. safety). There are a lot of things for the teams to consider in determining a reasonable course of action and coming up with a reasonable defense for their final decision.

Possible issues that need to be considered:

- How big are the flood events?
- Are changing climate patterns going to affect the size and frequency of flood events?
- What is the difference in cost to design to withstand the different levels of flood events?
- Are there unique landscape or bedrock concerns? How could we mitigate them?
- What are the population patterns downstream?
- How would downstream populations be effected by a failure at different flood levels?
- How do these kind of dams typically fail?
- Can the dam be constructed to fail elegantly and reduced the threat to downstream populations during flood events?

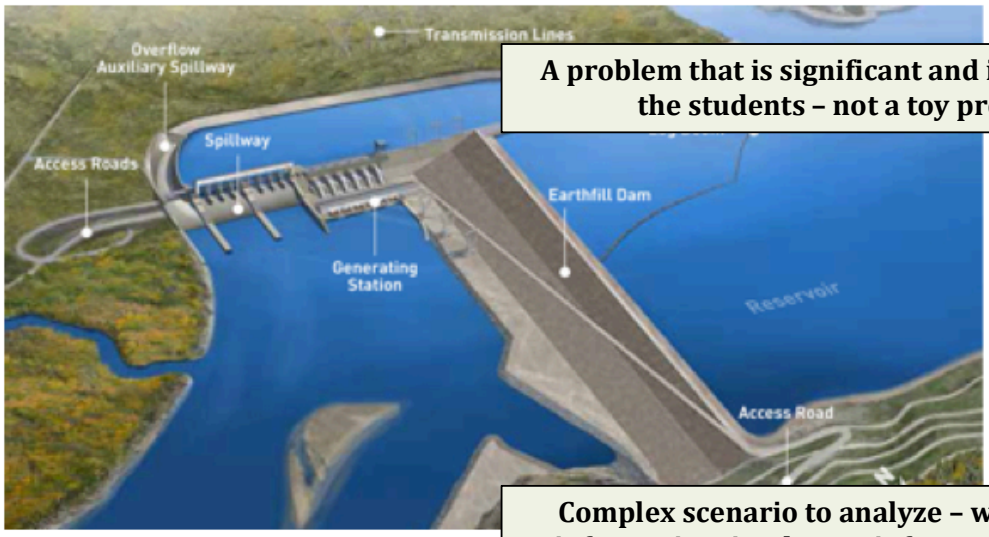
"Scenarios allow you to embed many variables that can be used to introduce multiple concepts, theories and perspectives into students' discussion, as well as to complicate the task, if desired, through a mix of relevant factors and red herrings." (Roberson and Franchini, 2014, p. 287)

TENET 4: CONSTRAIN CHOICE TO INTENSIFY ANALYSIS AND DISCUSSION

The example at first glance looks a lot like a multiple-choice question and many teachers worry that constraining choice like this will limit the depth of the discussion. It is quite the opposite, constrained choices focuses student energies on analysis of specific issues, which ultimately helps with team to team comparisons that allows students to see how their thinking contrasts other teams. But this would be like saying a murder trial is decided by a two option multiple-choice question. These kinds of constrained choice questions are potent discussion starters. This really becomes clear for all to see during the public reporting of team decisions.

"The function of the collective decision task, therefore, is to place a restrictive frame around the team's action. This restriction forces the team to evaluate, integrate and, if needed, respectfully discount a team member's inputs en route to a judgment and a focused decision." (Roberson and Franchini, 2014, p. 288)

"Tasks that direct students toward a specific choice do not stifle student thinking but concentrate it so that feedback on the task can be directed at specific, anticipated discoveries and realizations."
(Roberson and Franchini, 2014, p. 290)



A problem that is significant and interesting to the students – not a toy problem

Complex scenario to analyze – with relevant information, irrelevant information, missing information, constraints, trade-offs - that require expert-like concrete action

You are head of Engineering for a large da
Ningxai province of China. The dam is to b
exit of the Ordos Loop section of the river. The dam is to be located at 34°49'46"N
111°20'41"E. The Yellow river is China's third largest river. The river is characterized by extremely high silt loads, especially in spring floods. The local bedrock is highly fractured gneiss. The dam will be a concrete earthfill hybrid design. You have been asked to determine some of the main design parameters, including safety related question like what flood event return period to build the dam to withstand.

Specific question statement - that often uses superlatives like best next step, worst thing to do, most appropriate action, most likely outcome, greatest concern, etc.

What **flood return period** would you rec
withstand?

A) once in 50 year flood
B) once in 100 year flood
C) once in 200 year flood
D) once in 500 year flood

Multiple reasonable courses of action – some more reasonable than others

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CONTENTS

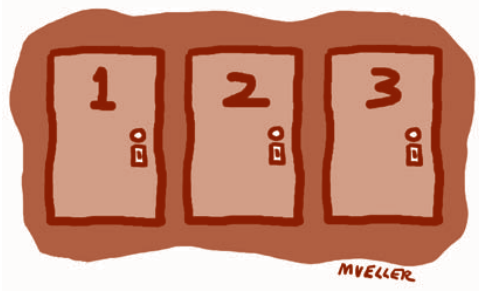
First-Day Questions for the Learner-Centered Classroom

Gary A. Smith
University of New Mexico

"Do my students know why I ask them to learn this way?" I said it aloud while reading the teaching evaluations from the previous semester. I had taken the plunge; I had moved substantially away from an almost entirely lecture-and-exam format in the second-semester geology course. Instead, many class sessions featured students working in small groups to apply content, which they first encountered largely through assigned reading, on to authentic geological problems.

Confronting a Problem

Each weekend, students completed an online assessment. Although low-stakes scores were provided for in-class and online assignments, these were primarily formative opportunities to guide both the students and me. Class sessions had been hugely more energetic and fun, at least for me. No dozing students, blank stares, and constant glances toward the clock. Students were doing things, and I was enjoying my interaction with them, guiding them when they were stuck and thrilled to contribute additional insights that they requested out of curiosity. My shorter presentations focused on topics that they were struggling with. Grades went up significantly.



So, why did these evaluations reveal so many signs of dissatisfaction? Why had my evaluation scores gone down while student achievement had gone up? The reason became clear as I read the written comments. The students were displeased with the greater work. They were content to ignore reading assignments, assuming that I would lecture over the content that was important. They were content not to review information and construct knowledge except by cramming the night before exams. However, in my class they needed to come to class prepared to do in-class assignments with their peers. Moreover, they had to be reviewing and applying what they had learned weekly for the online assessments. There were a few

comments about how much they had learned in the class, but for most students the cost seemed too high. Clearly, although I adopted what I was convinced was a more successful pedagogy for my students, the learners were so used to other approaches that they really did not know what I was doing and, more importantly, why I was doing it. Today, I realize that this is typical, but at the time, I did not know about resources (like Felder and Brent, 1996) to show me how to stay on track. What should I do?

Getting Student Buy-In

As the next offering of the course approached, I thought about what to do differently. Sure, I could make the workload more manageable—focus more on the learning outcomes by covering less content, assigning more succinct and purposeful reading, and giving clearer and shorter assignments and assessments to provide opportunity for reflection. However, was not the real problem that the students did not understand why I taught the course in this apparently unfamiliar style?

I planned to start the first day with a summary of the research on active and reflective learning. That would show them that I knew something about teaching and not just about geology and that they were really taking a "state of the art" course. Wouldn't they then see that everything I was having them do was really for their own benefit as learners?

As I outlined what I would say and what graphs I would show, I could not help but think that I was really missing the point. What I was planning somehow brought back from childhood memory the admonition of my parents to eat my vegetables. Just because it was good for me didn't make the food taste better; I still didn't like to eat some things. Wouldn't it be the same for the students? What I needed was a way to engage them to see that how I taught the course mattered to *them*; that learning this way helped them accomplish goals that were important to *them*.

> Why had my evaluation scores gone down while student achievement had gone up?

The First-Day Questions

On that anxious August day, I greeted the students and after a minimum of predictable first day review of the syllabus, I projected this text on the screen:

"Thinking of what you want to get out of your college education *and* this course, which of the following is *most* important to you?

1. Acquiring information (facts, principles, concepts)
2. Learning how to use information and knowledge in new situations
3. Developing lifelong learning skills."

It was a gamble—I had no idea how they would respond. I encouraged them to chat with their neighbors. Then I polled them. Two hands went up in support of option number 1. Twenty-one hands rose in support of option number 2. The remaining 13 students selected the final option. We talked about each one, with advocates for each stating their case. The two students who favored acquisition of information revealed that it was not so much that this option seemed most important but that it was most basic. They saw the list as hierarchical, and although they thought application of knowledge was more important than memorization, they felt that they had to master the factual information before they could use it. This led to further discussion of why learners needed to meet all three of these goals, even if we each held one as being more important than the other two.

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Now I had them where I wanted them. I projected a new question on the screen:

"All three of these goals are clearly important. However, let's think for a moment of how best to accomplish these goals. Learning is not a spectator sport—it takes work; that includes work in the classroom and work that you do outside of the classroom. So, of these three goals, which do you think *you can make headway on outside of class* by your own reading and studying, and which do you think would be best achieved in class *working with your classmates and me*?"

The polling was nearly unanimous that acquiring information was the easiest to do alone and that the other two goals seemed more complicated and would profit from peer and instructor influence. This, then, led to a discussion of how to pursue goals 2 and 3. These goals are not achieved by reading or listening to a lecturer—students must actively do things in order to learn. Students learn best (Davis, 1993) when they take an active role:

- When they discuss what they are reading
- When they practice what they are learning
- When they apply practices and ideas.

> They were content to cram the night before exams.

The need for active learning in class in order to reach their goals leads students to accept that they have to read and otherwise prepare before coming to class by making first contact with content on their own.

This discussion became a segue to explaining how the course was structured—that it was about their learning and achieving the goals that were most important to them. Rather than me lecturing over the assigned reading and leaving them to fend for themselves on homework, they were going to come to class having read, and sometimes struggled with, the text. The problem-solving that would apply the reading content and develop logical hypothesis statements and testing would take place in class. By completing these assignments and the online assessments, they would always know whether they were mastering both the content knowledge and its application and relationship to how scientists know about the natural world. Moreover, I would be continually reviewing their progress, too, working with individuals where they showed lack of mastery and going back to material when most of the class showed evidence of confusion and misconception.

> The results that semester were dramatically different. Not only was the active classroom fostering better learning performance on exams and other assignments but also my teaching evaluations rose to their highest levels.

The Impact

The results that semester were dramatically different. Not only was the active classroom fostering better learning performance on exams and other assignments but also my teaching evaluations rose to their highest levels. Students actually complained if they thought I was lecturing too much. I have since used the first-day questions in every course I teach and at all levels for three years. The strategy has been shared with colleagues through faculty development workshops and I frequently hear back about their experiences. Some use classroom response systems (clickers) to maintain anonymity during polling. The results are very consistent: Students desire to accomplish the educational goals that come from deep learning. One colleague, instructing a course of 100 students in a non-majors, general-education science class, has experienced situations where not a single student chose acquisition of factual knowledge as their prime learning objective. More importantly, all students prepare at some level for most classes, participate enthusiastically during in-class activities, and complete the assessments while acknowledging, sometimes with a reminder, that these learner-centered opportunities closely

match their own objectives.

The impact of the first-day questions to engage students with their learning is further enhanced by asking students to assess their preferred learning styles. By administering a free, online learning style inventory (e.g., Felder-Silverman Index of Learning Styles, **http://www4.ncsu.edu/unity/lockers/users/f/felder/public/ILSpage.html**) and spend-

ing a little time in class during the early weeks discussing the results, students commonly encounter for the first time that (a) they have particular learning style preferences, and (b) that different people learn in different ways. This exercise enhances the first-day questions by connecting active and reflective learning strategies in the course to the way the students learn, and it supports the use of a diverse toolbox of learning activities in order to assist a diverse group of learners to succeed.

Students may not have much experience with active learning or expectations placed upon them for their learning. The first-day question activity is important for getting student buy-in to why active-learning strategies are used, and to the partnership responsibilities of instructor and student. Without this introductory dialogue, the expectations of coming to class prepared, working with peers in class, and completing frequent assessments of learning may be foreign to students and seem like too much work compared to listening to lectures and regurgitating facts on exams. However, once students acknowledge the linkage between their goals and the implemented learning methods, they have a new appreciation for why learner-centered instructors do what they do and learners come to value these methods so long as they are used effectively and they can measure their own learning.

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References:

• Davis, B. G. 1993. *Tools for Teaching*. San Francisco: Jossey-Bass.
• Felder, R. M., and Brent, R. 1996. "Navigating the Bumpy Road to Student-Centered Instruction." *College Teaching*, v. 44, no. 2, 43-47.

Extending Smith's First Day Questions

Helping student buy-in to the flipped classroom

You can introduce students to TBL and why you are using it, with this mock Application Activity based on Gary Smith's activity from the National Teaching and Learning Forum Newsletter article *First-Day Questions for the Learner-Centered Classroom* (NTLF newsletter, 2008). The article asks the reader: "Thinking of what you want to get out of your college education and this course, which of the following is most important to you?"

1. Acquiring information (facts, principles, concepts)
2. Learning how to use information and knowledge in new situations
3. Developing life-long learning skills

The teachers will give time for intra-team discussion leading to a team decision. Then the teacher will pass out the TBL voting cards and ask the teams to simultaneously report by holding up the card that corresponds to their team's decision. Then you can facilitate a full class discussion contrasting the various team decisions. This activity both shows the students the mechanics of the Application Activity process and clearly surfaces differing student beliefs on what good classroom learning should look like. There is a wonderful way to extend this activity (Smith, 2013). At the end of the activity students are asked to revisit the items on the list and consider which of the items would be better achieved in class and which items could be achieved through individual study. They will quickly zero in on "acquiring information" as something they could do on their own. You can then revisit the format of TBL and show them that is exactly how TBL is structured, you acquire some information on your own and then come to class where we can work on higher order goals like application and life long learning skills.

References

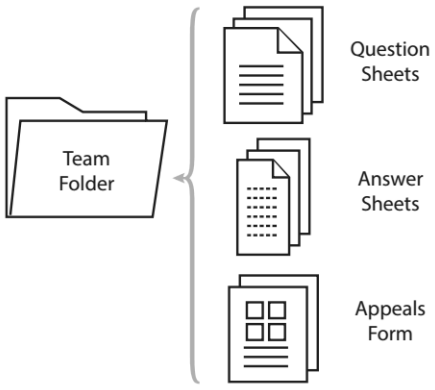
Smith, G. (2008). First-Day Questions for the Learner-Centered Classroom. *National Teaching and Learning Forum Newsletter.* Retrieved from http://www.ntlf.com/

Smith, G. (2013, November) Selling Active Learning to Faculty Requires a Student Purchase, Too. Session presented at 38th Annual POD Meeting, Pittsburgh, PA.

The RAP is like any other classroom activity, where preparation can help to make sure the process runs smoothly.

Pre-Class Preparation

Many teachers use team folders. Team folders are preloaded with the test question sheets, some kind of answer recording forms (maybe Scantron in larger classes), and an appeals form. Folders let you simplify the handling of materials. In large classes, we ask a team representative to come to the front of the class to pick up and drop off their team's folder, so the teacher remains at the front of the class. Creating these folders for each team not only simplifies getting materials to and from the teams; it sends the important message to your students that you have taken time to be organized.



Timing

The typical RAP takes 50-70 minutes for a 20-question test. In shorter classes, teachers will often shorten the RAP test. For our 50-minute classes, we often give 12-15 questions in 50 minutes; this gives us time to complete the entire five-stage RAP process. Many TBL practitioners now recommend even shorter 10 question RAPs, since student are often eager to get to 4S problem-solving main events.

Class Start

We start by announce there will be a RAP and how much time students will be given for the iRAT and tRAT. A general rule of thumb is three to five minutes for both folder distribution and time for students to get their names on the answer forms, then one minute per question on the iRAT, and slightly longer for tRAT (1.5 minutes per question). How long you need to give is ultimately controlled by the difficulty of the questions. Stray on the side of making questions easier, rather than harder. Hard or tricky questions can quickly burn up student goodwill. Be careful.

The iRAT (Individual Readiness Assurance Test)

To begin the Individual Readiness Assurance Test (iRAT), we ask students to put away any notes or other reading materials. We then ask one representative from each team to come to the front of the class to pick up their team's folder. Teams are not to open their folders until all

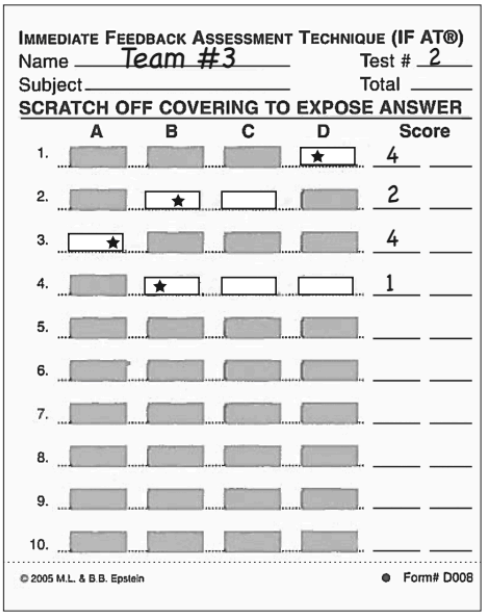
teams are reseated. Next, we ask the teams to open their folders, distribute the tests, and begin. While the students are completing the iRAT, we circulate around the room and clarify any difficulties that students may have understanding the questions.

Once the allotted iRAT time has elapsed, students are asked to collect their team's individual answer sheets and send one representative to the front of the room to exchange the answer sheets for their IF-AT card. Students are reminded to hang on to their question sheets for the team Readiness Assurance Test (tRAT).

Students who are absent on the day of a RAP typically receive a zero for both the iRAT and tRAT unless they have satisfied some other predetermined course requirements. These requirements could be to make plans with the teacher in advance to take the iRAT separately, to provide a medical note in order to be excused from the RAP and have the tests excluded from grading, or to require a signed note from their teammates with permission to share the team score. In this latter case, if a student has been a prepared and consistent contributor to the team, most teammates are happy to share their team score with the absent student.

The tRAT (Team-Readiness Assurance Test)

Before starting, we remind students of any decremental scoring scheme we might use with the IF-AT cards. On a four-option IF-AT card (A-D), we often award four points for a correct answer on the first scratch, two points for the second scratch, one point for the third scratch and zero if they needed to scratch all four possible answers. Different teachers use different decremental scales. Whatever scale you use, the important thing is that you are rewarding the students for continuing to discuss the question seriously. Otherwise, after one incorrect scratch, you would just rub the rest off and reveal all the other answers and a valuable learning opportunity would be lost.


IMMEDIATE FEEDBACK ASSESSMENT TECHNIQUE (IF AT®)
Name Team #3 Test # 2
Subject Total
SCRATCH OFF COVERING TO EXPOSE ANSWER

	A	B	C	D	Score	
1.				★	4	
2.		★			2	
3.	★				4	
4.		★			1	
5.						
6.						
7.						
8.						
9.						
10.						

 Form# D008

During the tRAT, we circulate around the room monitoring the students' progress. If we notice that a large number of teams are finished before the allotted time is up, we will ask the whole class who needs more time. If only a few teams need more time, then we will often announce that there are perhaps two minutes left (known as the 2 minute rule).

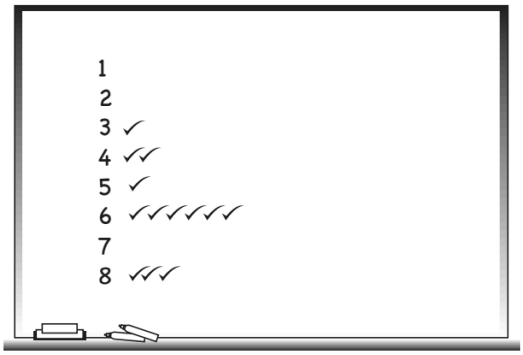
You write the question numbers on the board and ask teams to put check marks beside the question or questions they would like clarified. This is actually a very good option, since some concepts are clarified enough during the tRAT that students do not need further clarification. If you only work from the tally report of the individual tests, you may end up talking about topics that were already resolved during the team test.

Teachers often record the teams' average iRAT scores and the range of tRAT scores on the chalkboard. This achieves two goals. First, it shows students the value of working as a team, as tRAT scores are usually 10-20% higher than the average iRAT score. Secondly, it motivates teams to perform better than their peers by creating friendly competition.

The Appeal Process

At end of the team test (tRAT), teams are encouraged to appeal questions that they got wrong. Scholarly appeal arguments can be generated by any team and are written on the appeal form included in each team's folder. The teacher makes it clear that the appeals will only be considered outside of class time and that the results will be announced at the next class. Some student will try to open a conversation about why a particular answer should be considered correct; you can shut the conversation down by simply asking the team to complete that appeals form and you will look at it after class. You need to establish a rule of when appeals are due. Some teachers insist by end of class; other teachers insist by end of day, often submitted by email. One way to ensure that all team members have contributed to the appeal is to have them sign a statement of collaboration at the bottom of the appeal form.

Teacher Clarification/Mini-Lecture



At the end of the testing and appeal phases, teachers respond to items identified in the RAP as still challenging to students. You must **not** review the test question by question, but only review the questions and concepts that remain problematic for the students. Students like the mini-lecture since they know it won't be too long and the teacher is talking about something they know they don't know.

Ending Class Well

Students are asked to place all question sheets and the IF-AT form in their team folder for collection. We often get team members to sign the back of the IF-AT card, as this can simplify requests made by absent students who still want credit. We remind students that all question sheets must be returned or the whole team will receive a penalty, usually a mark of zero. We mark the folders with the number of students in each team; this lets us easily check that all question sheets are returned. A team representative is then asked to bring the team folder to the front of the room.

Read more in *Getting Started with Team-Based Learning* – page 74-113

4S Activity Facilitation

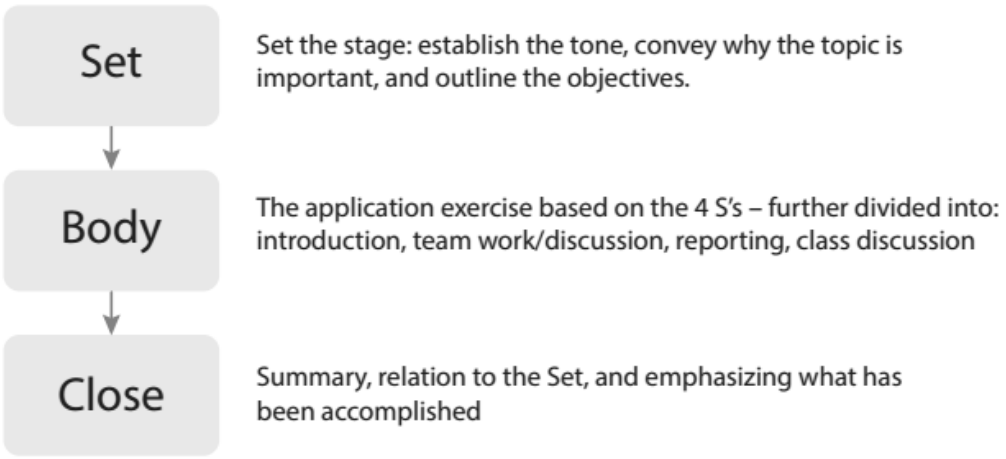
Classroom Logistics

"The design of a task is ultimately only as good as its execution and management" (Roberson and Franchini, 2014, p. 297).

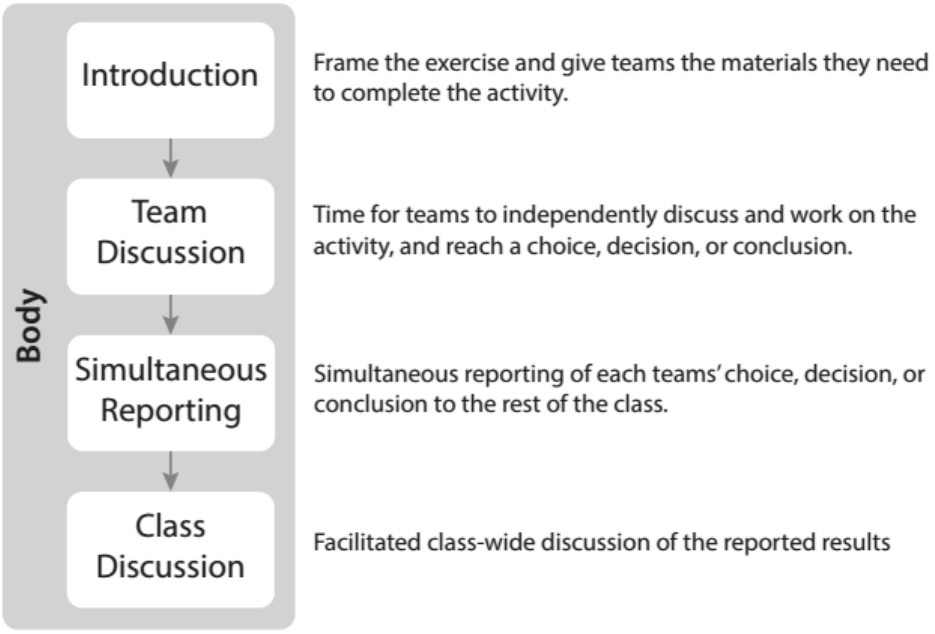
Many people new to TBL worry about facilitating the discussion after simultaneous reporting. Although we all have much to learn about facilitation, the good news is the 4S structure of TBL activities lead discussions that are simpler to facilitate than open general discussions.

Planning an Application Activity

The organization of an effective TBL Application Activity parallels that of any effective teaching activity; it needs a well-thought-out structure with a beginning, middle, and end. There are many frameworks used to describe such structures, but they generally have the same elements grouped in different ways. I will use one of the simpler top-level frameworks to describe structure: Set, Body, Close. Feel free to adapt your personal favourite if you have one.



Set, Body, Close is highly adaptable for almost any size group and any duration. It aligns, respectively, with the beginning, middle, and end of an activity or lecture. The Set portion sets the stage and primes the learners for what is to come; most importantly, it establishes the tone, conveys why the topic is important, and outlines the objectives. The Body is the core of the class; in a conventional lecture, this would be where the teacher delivers content, while in a TBL class, this is the Application Activity (including teams working on the exercise as well as the discussion and debriefing that follow). Finally, the Close wraps everything up. It summarizes the class or activity, emphasizes what has been accomplished, and relates the outcomes to the objectives from the Set.

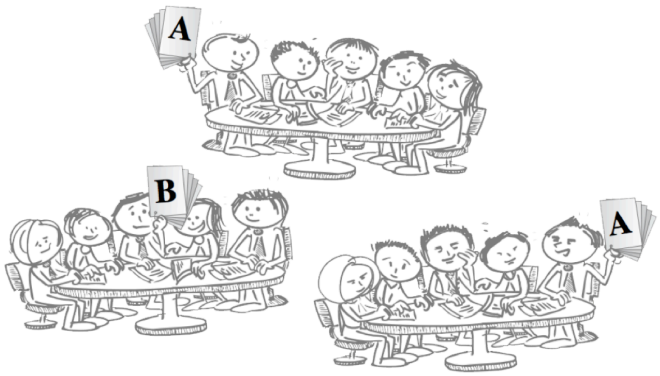


FACILITATING SIMULTANEOUS REPORTING

FIRST REPORT THE PATTERNS YOU SEE

The first thing you do, following simultaneous report, is announce the patterns you see...I see mostly A's and C's with a few D's - then you begin asking teams why they made their decision - going team to team and building a reasoned argument together with your students.

PROBE STUDENT THINKING



When teams commit to their positions and publically report it, the instructor can then facilitate the report by simply going team to team asking "why did your team pick A" going to another team "why did you pick B". You work the room going side to side and making sure to engage all parts of the room. Try to resist talking to teams next to you. This can become a conversation between the instructor and one team and not a conversation between all teams. One trick is to ask teams across the room to add their two cents. This helps the reporting conversation stay between students and not between instructor and one team of students. You can ask a team to tell you about their team's deliberations – what did they talk about, how did you decide...What is nice about this is you are only asking them to recount the conversation, not what is the right answer.

HELP STUDENTS BUILD A WELL CONSIDERED ARGUMENT

When discussion energy begins to wane you can begin to ask "why didn't you pick…" or "was there a second choice that your team considered?"…"why do you think someone might pick that choice?" These are the same kinds of questions that you need to use to play devil's advocate if all the teams agree.

It can be helpful to remember the components of a well-reasoned argument (Toulin et al, 1984)

1. CLAIM is made
2. GROUNDS (facts, evidence) are offered
3. WARRANT - connects claim to grounds
4. BACKING – a theoretical or experimental foundation for warrant is shown
5. Appropriate QUALIFIERS are used to temper claim (some, most, many, few)
6. Possible REBUTTALS are considered

Remembering the pieces of a well reasoned argument can help you push the students to deeper engagement, analysis. and argumentation.

CLOSING WELL – SO WHAT HAS BEEN LEARNED CAN BE REINFORCED

Another important consideration is to close the discussion well. You want to make sure students get reminded of the important take-aways, the assumptions examined, and the inferences that needed to be made. You can summarize or even better have the students paraphrase a summary of the discussion. Reflective one minute paper can be used to great effect here. You can simply ask students to quickly individually list the "3 most important points" or "2 remaining concerns" or "a context where it might not be applicable." A nice finish to this activity is to have teams compile these points into a team consensus worksheet. However you do it, not closing activities well robs them of some of their value.

Read more in *Getting Started with Team-Based Learning* – page 114-142

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TBL Module: Categorical Data and Chi-Square

Table of contents

Introduction

This module is one I use in my advanced psychological statistics course. The name of the course is deceptive; it is actually intermediate level. I discovered early on that students often remembered little from their introductory course so my class has evolved to the point where I spend the first half of the semester reviewing introductory statistics topics at a deeper level; I then move to new material after the midterm.

Most of the topics in this module are covered in introductory statistics classes and the concepts are quite elementary. Yet I find that students have a great deal of trouble understanding these statistical techniques. It may be because it's often the last topic covered in the introductory course and instructors may not have enough time to do it justice. Whatever the reason, this module requires more repetition of concepts than would seem necessary or appropriate for a class at this level. But I like the application activities, as do the students who find them very useful. This module typically requires 4 to 5 hours of class time.

Reading assignment and learning outcomes

I use a textbook for this course and, in the first half of the semester, cover approximately one chapter per week. The reading assignment for this module is Ch. 6 in David Howell's (2013) *Statistical methods for psychology* (8th Ed.). Belmont, CA: Thomson.

I create a "reading guide" for each module which is, essentially, the learning outcomes. I don't expect my students to understand the entire chapter without some help. I highlight the outcomes that will be covered by RAT questions, but students understand that for the midterm/final they are responsible for understanding all of the listed concepts.

- **I can describe the characteristics of the chi-square distribution.**
- **I can define the terms expected and observed frequencies.**
- **I can perform a chi-square goodness-of-fit test by hand and using statistical software, and can interpret the results.**
- **I can perform chi-square contingency table analysis (test of independence) by hand** and using statistical software**, and can interpret the results.**
- I can describe the problems associated with small expected frequencies.
- **I can describe the assumptions associated with chi-square.**

- I can describe one way to handle dependent or repeated measurements using chi-square.
- I can explain and demonstrate how to calculate d-family and r-family measures of effect size.
- I can explain and demonstrate how to calculate kappa.

Plan of class

- iRAT and tRAT
- Introductory application activity: What kind of chi-square? (see p. 5)
- Mini-lecture: Introduction to chi-square
- Challenge! Teams are presented with data we used earlier in the semester for an activity on distributions and hypothesis testing. The data are most appropriately analyzed using chi-square. I give the teams a few minutes to see if they can figure out what kind of chi-square to use, and return to the problem later.
- Mini-lecture: Chi-square goodness of fit test
- Students work on a goodness of fit test problem (done by hand) within their teams; we discuss the results as a class.
- Mini-lecture: Chi-square test of independence
- Students work on the challenge problem (done by hand) within their teams; we discuss the results as a class.
- Mini-lecture: Assumptions of chi-square
- Mini-lecture: Effect size measures
- Students work on effect size problems (done by hand) within their teams; we discuss the results as a class.
- Students work on two problems using the computer and SPSS
- Final team activity: "Meditation increases compassionate responses to suffering" (see pp. 7-8)

Readiness Assurance Test

1. In a chi-square test, the variables are:
   a. interval level.
   b. rank-order (ordinal).
   c. ratio scale.
   d. categorical (nominal).

2. The values in a chi-square distribution are always greater than 0 and:
   a. less than 1.
   b. are normally distributed.
   c. can be quite large.
   d. are negatively skewed.

3. The main idea of a chi-square test is that you:
   a. test the estimated degree of fit (proportion of variance accounted for) of one variable to the other variable.
   b. test how well the pattern of observed frequencies fits some expected pattern of frequencies.
   c. compare the estimated population variances, to see if they vary from each other more than by chance.
   d. compare the estimated population means, to see if they vary from each other more than by chance.

4. The degrees of freedom for the chi-square goodness of fit test are the:
   a. mean number of individuals per category, minus 1.
   b. number of categories minus 1.
   c. mean number of individuals per category, minus the number of categories.
   d. total number of individuals, minus the number of categories.

5. In a chi-square goodness of fit test, the null hypothesis is that the:
   a. number of people in one category is no greater than the number of people in the other categories.
   b. variances of the populations of categories are the same.
   c. means of the populations of categories are the same.
   d. observed proportion of people over categories does not depart from what is expected by chance.

6. In chi-square, the expected frequencies are the frequencies we would expect if the:
   a. null hypothesis is true.
   b. null hypothesis is false.
   c. research hypothesis is true.
   d. research hypothesis is false.

7. Contingency table analysis is sometimes called the chi-square test of independence. This is because, under the null hypothesis, the:
   a. variables are not related.
   b. variables in the table should never be compared.
   c. observed frequencies are larger than the expected frequencies.
   d. distribution of one variable varies over different levels of the other.

8. The degrees of freedom for a contingency table analysis is the:
   a. total number of category levels minus 1.
   b. number of categories minus 1.
   c. number of participants minus the number of cells.
   d. number of columns minus 1, times the number of rows minus 1.

9. One advantage of the chi-square test over most other inferential statistical procedures is that it:
   a. can use the distributions of any other statistical procedure as a comparison.
   b. has minimal assumptions about populations.
   c. can be easily applied to repeated-measures designs.
   d. does not require as many participants.

10. Which of the following would ***NOT*** be allowed in an ordinary application of the chi-square test?
   a. The number of successes of an advertisement is compared for three different groups of people to see if the number of successes is equal for the three groups.
   b. Tall and short people are compared on which religion they belong to.
   c. The number of people of different ethnicities working in a particular company is compared to the proportions of those ethnicities in the general public.
   d. Students' preference for studying while sitting or lying down is assessed as sophomores and then again as seniors.

Introductory application activity

For this activity, each team is given a sheet with the following scenarios and response options, as well as a small whiteboard and marker. Teams are given a couple of minutes to read each scenario and there is a race to see which team will hold up its whiteboard with an answer first. When there is disagreement, teams are asked to defend their answer. This activity generates a great deal of energy and gets students ready to explore topics in greater depth.

What kind of chi-square?

1. A gym wanted to assess member satisfaction with a new fitness program. They compared members who had joined the fitness program to members who had not joined the fitness program by asking them whether they were satisfied or not satisfied with their weight loss in the last six months. They hypothesized that members who had joined the fitness program were more likely to be satisfied with their weight loss.
   a. Chi-square goodness of fit test
   b. Contingency table analysis (chi-square test of independence)
   c. This can't be analyzed using a chi-square!!

2. A pharmaceutical company wants to determine whether a sleeping pill is effective. They randomly assign individuals either to take a sleeping pill or to take a placebo. They compare the amount of time participants are asleep. They hypothesize the sleeping pill group will sleep longer than the placebo group.
   a. Chi-square goodness of fit test
   b. Contingency table analysis (chi-square test of independence)
   c. This can't be analyzed using a chi-square!!

3. In a poll 200 residents in a small town were asked whether they supported the construction of a new mall. They responded whether they did, they didn't, or whether they had no preference.
   a. Chi-square goodness of fit test
   b. Contingency table analysis (chi-square test of independence)
   c. This can't be analyzed using a chi-square!!

4. A company that stocks a vending machine wants to optimize sales. The company offers five different beverage options and wants to know whether some beverages are more popular than others. To determine this, the numbers of beverages of each kind sold in one week are counted.
   a. Chi-square goodness of fit test
   b. Contingency table analysis (chi-square test of independence)
   c. This can't be analyzed using a chi-square!!

5. An ad agency wants to see if a set of complimentary pens they've designed are gender neutral. They place both their green and yellow pens in a can and keep track of how many males and females pick up each color of pen.
   a. Chi-square goodness of fit test
   b. Contingency table analysis (chi-square test of independence)
   c. This can't be analyzed using a chi-square!!

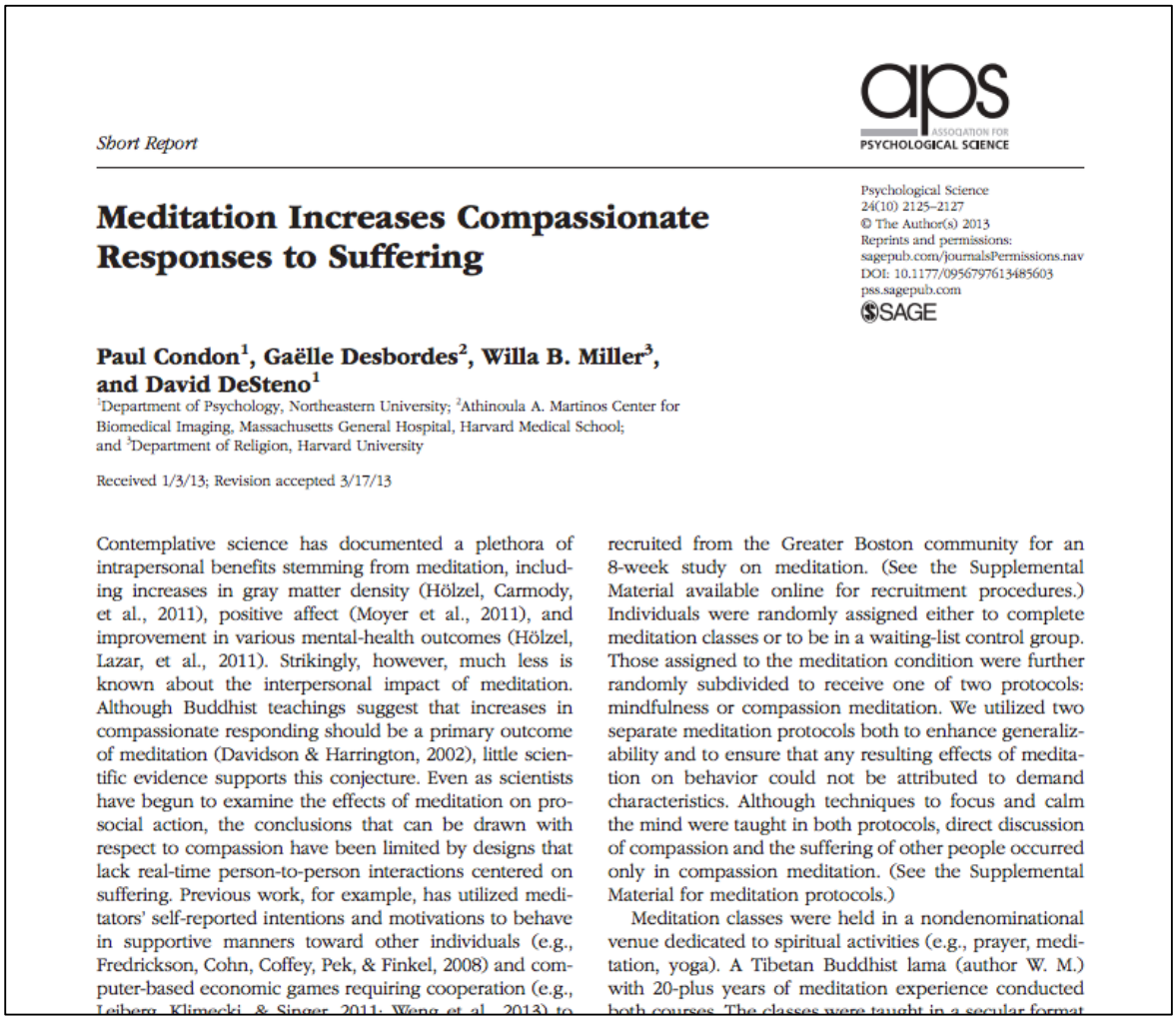
6. A researcher is testing how effective a list of words is at causing subjects to recall a specific word that was not listed. The researcher collects data from males and females during their freshman year, and then again during their sophomore year and then compares each person's data from the two years.
   a. Chi-square goodness of fit test
   b. Contingency table analysis (chi-square test of independence)
   c. This can't be analyzed using a chi-square!!

Final application activity

For this activity, students are given the introduction and method section of the following article (see file meditation_compassion) : Condon, P., Desbordes, G., Miller, W. B., & DeSteno, D. (2013). Meditation increases compassionate responses to suffering. *Psychological Science, 20,* 1-3.

After reading these short sections, students complete a worksheet as a team, which I collected at the end of class. This article works perfectly for two reasons. First, it only reports and discusses two statistics, both of which appear in this module (chi-square and odds ratios). Second, after taking a contemplative pedagogy workshop in August, I integrated mindfulness techniques through the entire semester of this particular class, so students were primed to be interested in the topic.

While this is not a traditional 4S activity, it pulled several pieces of the module and course, in general, together and was a good ending to the topic.



Short Report

aps ASSOCIATION FOR PSYCHOLOGICAL SCIENCE

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Meditation Increases Compassionate Responses to Suffering

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Contemplative science has documented a plethora of intrapersonal benefits stemming from meditation, including increases in gray matter density (Hölzel, Carmody, et al., 2011), positive affect (Moyer et al., 2011), and improvement in various mental-health outcomes (Hölzel, Lazar, et al., 2011). Strikingly, however, much less is known about the interpersonal impact of meditation. Although Buddhist teachings suggest that increases in compassionate responding should be a primary outcome of meditation (Davidson & Harrington, 2002), little scientific evidence supports this conjecture. Even as scientists have begun to examine the effects of meditation on prosocial action, the conclusions that can be drawn with respect to compassion have been limited by designs that lack real-time person-to-person interactions centered on suffering. Previous work, for example, has utilized meditators' self-reported intentions and motivations to behave in supportive manners toward other individuals (e.g., Fredrickson, Cohn, Coffey, Pek, & Finkel, 2008) and computer-based economic games requiring cooperation (e.g., Leiberg, Klimecki, & Singer, 2011; Weng et al., 2013) to

recruited from the Greater Boston community for an 8-week study on meditation. (See the Supplemental Material available online for recruitment procedures.) Individuals were randomly assigned either to complete meditation classes or to be in a waiting-list control group. Those assigned to the meditation condition were further randomly subdivided to receive one of two protocols: mindfulness or compassion meditation. We utilized two separate meditation protocols both to enhance generalizability and to ensure that any resulting effects of meditation on behavior could not be attributed to demand characteristics. Although techniques to focus and calm the mind were taught in both protocols, direct discussion of compassion and the suffering of other people occurred only in compassion meditation. (See the Supplemental Material for meditation protocols.)

Meditation classes were held in a nondenominational venue dedicated to spiritual activities (e.g., prayer, meditation, yoga). A Tibetan Buddhist lama (author W. M.) with 20-plus years of meditation experience conducted both courses. The classes were taught in a secular format

Team:

Meditation increases compassionate responses to suffering

1. Read the introduction and method sections of the article.

2. What is the research hypothesis (is there more than one hypothesis)?

3. What is the null hypothesis?

4. The authors did not find a difference in behavior as a function of meditation protocol; therefore, the analysis uses data that collapsed participants in the two meditation conditions. The results of the study are below.

	Meditation training	Waiting-list control	Total
No help	10	16	26
Help	10	3	13
Total	20	19	39

a. What type of analysis should be done on these data? Perform the analysis; report and interpret your result below.

b. Calculate an *r* measure of effect size; report and interpret the result.

c. Calculate the odds ratio (a *d* measure of effect size); report and interpret the result.

5. What are you overall conclusions about this study?

6. Do you notice anything interesting about the data? What questions are you left with?

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TBL Module - Developing & Testing Your Own Stock Screen

Context for this module

This module is taken from an introductory undergraduate course in investments and has student teams create their own stock screen using a computer database containing financial information for approximately 9,000 publicly traded companies. Students must develop criteria to screen the database for high potential stocks as of a given past date and then test to see how these stocks would have done after the historical purchase date. Stock screening is one of six modules in the course. The other five are equity analysis, fixed income securities, options/futures, mutual funds/exchange-traded funds, and portfolio theory.

1. What are the goals and objectives of this lesson?

This module is useful for students interested in careers in investments, especially as an equity analyst. Stock screening is a valuable starting point in stock selection, but it is important to emphasize the need for further fundamental analysis of each stock. After completing the module, students should be able to:

a. Identify stock characteristics that have historically led to high-performance.
b. Identify screening criteria that are invalid or illogical.
c. Optimize a back-tested stock screen.

2. Give a brief description of the pre-class preparation.

In addition to assigned reading for this module, students must also individually work through a tutorial that I developed to help them understand how to screen and back-test a screen using the stock database. Their work with the tutorial is not graded, but the students understand that doing well on the RAT and the team application activity is dependent upon working through the tutorial carefully. The tutorial is included in this document at the end of the instructions for the team application activity.

3. Show the readiness assurance tool (RAT).

Below is a ten-question RAT with the answer key.

4. Show the application exercises and how the answers will be managed by the teacher/facilitator of the TBL session.

The instructions for the team application activity are at the end of this document. Below is a summary of how this activity adheres to the four Ss:

Significant problem: This activity provides students with hands-on experience screening a stock database. They not only learn the technique for screening and back-testing the screen to optimize it, but they also get to work with the type of data that practitioners use. This problem is also significant in that students could test endless combinations of criteria in order to optimize their screen. There is no correct answer,

only the highest return-to-risk ratio in the class and comparisons to what other teams have done in previous semesters.

Same problem: All teams are trying to optimize a stock screen using the same database so that they can compare results (screening criteria) to the other teams.

Specific choice: Each team will be reporting the screening criteria which they hope will lead to the highest return-to-risk ratio of any team in the class.

Simultaneous report: After using their computers to develop and test their screening criteria, each team writes its best set of criteria on an anonymous poster to hand in to the instructor at the deadline. The instructor tapes these posters to the classroom walls for a gallery walk. Teams are trying to identify invalid and illogical criteria, and they are voting for the screen (other than their own) which they believe will result in the highest return-to-risk ratio. A classroom discussion follows where teams have to justify their choice and explain any invalid or illogical criteria they found.

5. Describe any other aspects of the module or the course you find relevant (e.g. course content, peer evaluation, grading, appeals process, facilitator notes.)

Appeals Process: Students can appeal an incorrect answer on the tRAT. I use the appeals process as explained in the Michaelsen, Knight, and Fink book (2004).

Peer Evaluation: Students do peer evaluation twice during the 13-week semester, once during Week 5 and then again at the end of the course. The Week 5 evaluation is not included in the course grade, but is designed to give each student performance feedback from the team and to give each student practice in providing constructive criticism. Students answer two questions for each teammate and him or herself:

What has been Teammate X's most significant contribution to the team?

In what way could Teammate X most improve his or her contribution to the team?

This feedback is given to each student without revealing the name of the evaluator. Students lose points if they do not hand in an evaluation for each teammate, or if they do not make a serious attempt at providing constructive criticism. There is no quantitative part to this first peer evaluation.

At the end of the course, students answer the same two questions plus a question on if and how the teammate has improved between the two evaluations. In addition each student must divide up a point total (10 points times the number of teammates, excluding the evaluator) among the teammates with the requirement that the same number of points cannot be given to every teammate (at a minimum, one teammate must receive a 9 while another one receives an 11). These points are included in the final course grade.

1. The primary purpose of creating a stock screen from a stock database is
   A. to remove bias and emotion from the stock selection process.
   B. to identify stocks characteristics which have historically proven to be successful.
   C. to provide a starting point for further analysis of the stocks on the screened list.
   D. to gain an appreciation for the fact that one or two excellent stocks can overcome a number of mediocre or poor stocks.

2. The Stock Investor Pro database includes pre-defined stock screens based on the screening principles of well-known investors. Which one of the following statements about these screens is FALSE?
   A. The creators of the database developed the screens by reading books about the investor's style.
   B. These pre-defined screens have been tested over many years, so the resulting stocks should be purchased without further analysis in order to remove bias from the selection process.
   C. The screens are tested over many years by running them monthly and adjusting the stock holdings each month.
   D. Cash dividends are not included in the returns from testing the pre-defined screens.

3. Which of the following statements best summarizes O'Shaughnessy's Cornerstone Growth Strategy?
   A. Select stocks with strong earnings growth, but don't pay too much for them (low price-to-sales ratio).
   B. Select values stocks (low price-to-sales ratio) of large companies (market capitalization > $150).
   C. Select a well-diversified portfolio (50 companies) of large company (market capitalization > $150) value stocks (low price-to-sales ratio).
   D. Select stocks that the market likes (rising price), but don't pay too much for them (low price-to-sales ratio).

4. Related to screening a stock database, which one of the following statements is FALSE?
   A. *Back-testing* means that you assume you are at some date in history with no knowledge of the future. Screen the database as of that date and see how the selected stocks would have done in the future.
   B. *Survivor bias* results from the fact that a stock database includes companies that existed in the past, but went out of business.
   C. Including a minimum liquidity criterion in a screen is important because there are many stocks in the database that cannot be bought or sold at a fair price.
   D. All valuation criteria must include the purchase price of the stock.

5. The annual rate of return of a portfolio can be calculated by adding up the annual return for each stocks in the portfolio and dividing by the number of stocks in the portfolio. This simple method can be used only if a certain assumption is true. Which one of the following assumptions must be true?
   A. All of the stocks are purchased at the same time.
   B. None of the stocks can have a negative annual return.
   C. An equal dollar amount is invested in each stock.
   D. All of the stocks are sold at the same time

6. Maximizing the historical annualized rate of return through back-testing would seem to be best way to measure the success of a stock screen because investors want the highest return possible. Why is it preferable to try to maximize annual return divided by risk (standard deviation of returns) instead?

A. Screens that have significant losses on their way to high returns might cause the investor to sell out of fear before the high returns can be realized.
B. Risk and return are positively correlated. Finding high risk stock screens is one way to maximize return.
C. Using return divided by risk is required to make apples-to-apples comparisons between stock screens.
D. Including risk in the formula allows one to compare results to published statistics from the Securities and Exchange Commission (SEC).

7. Which of the following statements best summarizes the "ten-bagger concept?"

A. A stock (not purchased on margin) can only lose 100% of its cost, but there is no limit to how much it can gain (200%, 500%, 1000%, etc.).
B. A low-priced stock that increases in value by ten times its cost or more will make almost any stock portfolio profitable.
C. Screening a stock database is the highest-probability way to identify a stock that multiplies in value.
D. Stocks under $10 per share have the best chance of gaining significantly in value.

8. Assume that you are using the Stock Investor Pro database to test a stock screen as of the date, M13. One of the following criteria for this test is invalid. Which one is it?

A. P13/P25-1 < .40
B. Sales Y1 > Sales Y2
C. P13/(Sales Y2/Shares Average Y2) < 1.5
D. PE-Average Y3 < 20

9. Assume that you are using the Stock Investor Pro database to test a stock screen as of the date, M13. All of the following criteria are valid. Which one is the LEAST logical?

A. P13 < 5
B. P13*Price-Volume M013/21 > 1000
C. Return on equity Y2 > 15
D. P13/EPS-Continuing Y2 > 90

10. Assume that the back-testing of your screen results in the following four annual returns: 10%, -20%, 40%, and 30%. Which of the following formulas correctly calculates the return-to-risk ratio in Excel?

A. =((.1*-.2*.4*.3)^(1/4))/STDEV(.1,-.2,.4,.3)
B. =((1.1*.8*1.4*1.3)^(1/4)-1)/STDEV(1.1,.8,1.4,1.3)
C. =((1.1*.8*1.4*1.3)^(1/4)-1)/STDEV(.1,-.2,.4,.3)
D. =((.1*-.2*.4*.3)^(1/4))/STDEV(1.1,.8,1.4,1.3)

Answer Key: 1C 2B 3D 4B 5C 6A 7A 8B 9D 10C

Mgt. Studies 380: Investments
Prof. Rick Goedde

Developing & Testing Your Own Stock Screen

Overview & Project Objectives

Your team will develop criteria for a stock screen using the Stock Investor Pro (SI) database and then test the screen over four years. The goal is to maximize the return-to-risk ratio (average annual portfolio return over the four years divided by the standard deviation of those returns). This project involves reporting only your best screening criteria to the class. Stock screening is a valuable starting point in stock selection, but it is important to emphasize the need for further fundamental analysis of each screened stock. After completing this project, you should be able to:

d. Identify stock characteristics that have historically led to high-performance.
e. Identify screening criteria that are invalid or illogical.
f. Optimize a back-tested stock screen.

Detailed Instructions

1. Each person on your team should work through the tutorial starting on page 3 of this document. We will discuss this tutorial in class. Feel free to e-mail questions to me, call or visit during office hours (or set up an appointment for a different time), or ask questions about the tutorial in class. Working through this tutorial will help you to do well on the RAT and the team application activity itself.

2. Use the SI database to develop a stock selection screen. Your goal is to maximize the return-to-risk ratio. You must have exactly five stocks in your portfolio each year. This means that one of your criteria must have a variable minimum or maximum parameter to get exactly five stocks.

3. Calculate your portfolio return for each of the following four years:

a. April 30, 1998 (M049) to April 30, 1999 (M037)
b. April 30, 1999 (M037) to April 30, 2000 (M025)
c. April 30, 2000 (M025) to April 30, 2001 (M013)
d. April 30, 2001 (M013) to May 3, 2002 (M001)

Over the first two years, the S&P 500 index rose 31 percent (a bull market). Over the last two years, the index fell 26 percent (a bear market). This will allow you to test your system over very different market conditions.

4. One of the criteria in your screen must insure that daily dollar trading volume is $100,000 or greater. Specifically, [Price M049]*[Price-Volume M049]/21>=100 for the first year. You must change the month number for the three subsequent years. This criterion cannot be the variable one to get to five stocks. Liquidity is so important in buying stocks that this criterion is required.

5. Be sure to avoid using data which didn't exist at the time the screen would have been run. The screen is run four times: M049, M037, M025 and M013. This means that you will have to create more custom data fields than if you were running the screen as of the last date in the database. Violating this requirement is a fatal flaw in doing stock screening research and invalidates your results.

6. Be sure to show the detailed formula for any custom data field you create. The reader has no other way of knowing what you did.

7. Growth rates can only be three years long because there are only three years of data in the database prior to M049 (April 30, 1998). You can't use four years of data at M037 just because it exists – you must be consistent between years.

8. KEEP IT SIMPLE!!! Remember that you must test your screen over four years, and that it will involve trial-and-error to come up with the best criteria. Reduce your workload by keeping it simple. You need some way to identify "good companies" (at least one "quality" criterion), and some other way to make sure that they are reasonably priced (one "valuation" criterion). Quality and valuation are the two key underlying concepts of most successful screens. You should also make sure that the stocks have adequate liquidity (the average dollar amount that is traded in a day or month must be high enough). Some advice: Lower priced companies tend to do better because of the ten-bagger concept.

9. Rank the five stocks for each year by purchase price from lowest to highest. Create a view which includes the company name, industry, the purchase price, the return over the next year, and all other data fields which you screened for. Export the view to Excel. Be sure to give a descriptive label to all column headings (For example, don't label a column as Udef6.) Calculate the portfolio return for each year (average of the five stocks), the compounded average of the four annual returns, and the standard deviation of the four annual returns. Finally, divide the four-year compounded average return by the standard deviation to get the return-to-risk ratio. It is this ratio that you are trying to maximize.

10. You will be writing the criteria for your best screen on poster paper that I give you for display to the entire class. Do not put your team name, or any other identifying information on it. Each team will analyze the screen of the other teams, identify any invalid or illogical criteria, and vote for the screen most likely to succeed (highest return-to-risk ratio).

Tutorial to Test a Stock Screen

Introduction

The purpose of this tutorial is to give you some experience using a stock database to test the performance (rate of return) of a stock screen over a two-year period. The idea is to go back in time and assume today is a particular historical date, and that you have no knowledge of the future beyond that date. As of that date, you enter specific criteria into the database and screen for the best five stocks out of 8,875 stocks in the Stock Investor Pro database. You can then check the five stocks to see how they did in the "future".

In this system, the investor owns stocks for one year (April 30 to April 30) and then reruns the screen to find stocks to buy for the next year and so on. You will analyze the system over the following two periods: April 30, 2000 to April 30, 2001 and April 30, 2001 to May 3, 2002 (the database you are working with ends on May 3, 2002).

Detailed Instructions (First review the *Joys of Stock Picking* exercise)

Create six custom data fields – three data fields for each year. Click on the Custom Field Editor (triangle icon) and maximize the screen. If you need help, use the Contents part of the Help system to learn about creating your own custom data fields. The three fields for 2001-02 are:

a. [Price M013]/([Sales Y2]/[Shares Average Y2])
b. [Price M013]*[Price-Volume M013]/21
c. [Price M001]/[Price M013]-1

Note: Once you have created the data fields for 2001-02, the easiest way to create the other year is to backspace month and year numbers out and type in the new numbers. You then save the field with a new name. This is quicker than creating the custom fields from scratch.

Price M001 is the closing price of the stock on May 3, 2002, the last date in the database. Price M002 is March 29, 2002 and so forth, counting months backwards. The earliest price in the database is Price M120, or May 31, 1992. Sales Y2 are sales for the calendar year 2000 (the first year before the April 30, 2001 buy date), Y3 is 1999, etc.

Field a. is called the *price-to-sales ratios*, equaling the price on April 30 divided by the latest fiscal year sales per share. This is a measure of value used to insure that only reasonably priced stocks are purchased. A price-to-sales ratio of .35 can be thought of as paying $.35 for $1.00 of sales per share. Your other data fields will use Sales and Shares Average from Year 3 (Y3).

Field b. is an estimate of the average daily dollar trading volume of the stock during April, 2001. This is the amount of stock (in dollars, not shares) that exchanged hands on an average day. High volume is desirable because it is easier to get transactions executed, and usually means a smaller bid-ask spread. Dividing by 21 converts a monthly number to daily because there are 21 trading days in a month on average.

Field c. is "the future". It is calculating the one-year rate of return (April 30 to April 30) for the stock. You will calculate the five-stock portfolio rate of return from April 30, 2000 to April 30, 2001 and from April 30, 2001 to May 3, 2002.

Note: Be careful when counting months back from M001 (May 3, 2002). As a check figure, the earliest price you need for this assignment is M025 (April 30, 2000).

Create a screen for each year to find five high-potential stocks out of the 8,875 stocks in the database. Click on the Screen Editor (funnel icon) and maximize the screen. If you need help, use the Contents part of the Help system to learn about creating screens. The screen has five criteria (you will have to change the variables for each of the two years, but the following list is for 2001-02):

a. Exchange Not equal Over the counter [Find it in Company Information]
b. [Price M013] >= 1 ($1.00)
c. [Price M013] <= 3 ($3.00)
d. [Price M013]*[Price--Volume M013]/21 >= 500 ($500,000)
e. [Price M013]/([Sales Y2]/[Shares Average Y2]) <= .35

Use the custom fields you created for Criteria d. and e. Click on *How Many* to see how many stocks fulfill all five criteria. Adjust the .35 in Criterion e. up or down until you have exactly five stocks. The 500 represents $500,000 of stock changing hands on average each day during April, 2001. Save as *2001 Screen.* Click *Apply*.

Rank the five stocks by purchase price from lowest to highest. Click on *Tools* in the upper left corner of the screen, then *Rank*, then the + sign before Prices – Monthly Close, then Price M013 and *Ascending*, then *OK*.

Create a view for each year so that your computer screen will show only the fields (columns) that you're interested in, rather than every field available. Click on the View Editor (eye glasses) and maximize the screen. If you need help, use the Contents part of the Help system to learn about creating views. The view has seven fields (you will have to change all of the fields except Company name and Industry to correspond to 2000-01, but the following list is for 2001-02):

a. Company name (find it under Company Information)
b. Industry (Company Information)
c. [Price M013] (Prices – Monthly Close)
d. [Price M001]/[Price M013]-1 (Custom Fields)
e. [Price M013]*[Price-Volume M013]/21 (Custom Fields)
f. [Price M013]/([Sales Y2]/[Shares Average Y2]) (Custom Fields)
g. Sales Y2 (Income Statement – Annual)

Save as 2001 *View*. In the upper right corner of the screen, choose *2001 View* from the drop-down menu. Export the view to Excel (refer to Step 6 in the Introductory Exercise for SI if you forgot how to export).

Find the average (mean) of Column D for both years. Note that Column D is the one-year rate of return for the stocks you selected. If you put equal dollars into each of the five stocks, the average of Column D would be the rate of return for the portfolio.

Assume that you also ran the above screen for 1998-99 and 1999-2000, and got 30% and 50% returns for the portfolio, respectively. Calculate the average annual compounded rate of return for the portfolio over the four-year period. Use Excel and the following formula =((1+w)*(1+x)*(1+y)*(1+z))^(1/4)-1, where the four variables are the portfolio rates of return for the four years. Note that we are ignoring any dividends paid on these stocks. You should get an answer of approximately 111%.

Use =STDEV( ) to calculate the standard deviation of the four rates of return. Divide the average return by the standard deviation to get a ratio – the percentage return for one percent of standard deviation, or return-to-risk ratio. You should get an answer of approximately .8.

TBL Module Exemplar in Mechanical Design

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Context

- 3rd year undergraduate course on mechanical design with an emphasis on analysis tools used to design functioning components
- Meetings:
  - 2 x 50-minute class / week (1 section)
  - 1 x 2-hr tutorial (with TA) (3 sections)
- Students
  - 140
  - Teams of 5 (some 6), formed from like disciplines for scheduling but otherwise random
- Module topics
  - 0 Review (2 weeks)
  - 1 Fracture (2 weeks)
  - 2 Fatigue (2 weeks)
  - 3 Shafts (2 weeks)
  - 4 Welding (2 weeks)
  - 5 FEA computer modelling (2 weeks)
  - Course review (1 week)
- Tiered lecture theatre

Grade Distribution

- 15% RAP (7.5% iRAT and 7.5% tRAT*)
- Assignments (20% team*, 10% individual for peer assessment tasks on peerScholar)
- Midterm 20%
- Final exam 35%

*team items are multiplied by a peer evaluation score, based on 3 iPeer evaluation. Mean peer evaluation is 100 in a team – some are above, some are below.

Readings

Modules 1-5 each have assigned pre-readings from the course text. The text is large and information-dense. Each module topic above is a chapter of approximately 40-60 pages. Reading guides are used to focus on key elements and to make the readings more digestible and less daunting. Readings are divided into three categories:

- **Required**: the primary source of material for RAP quizzes (15-20 pages)
- **Beneficial**: additional materials to support the required readings (10-15 pages)
- **Supplementary**: nice-to-know material, not required for the course (balance of chapter)

The expected time commitment for the readings is approximately 1-hr every two weeks.

Example readings are provided.

Readiness Assurance Test

- 15 questions, A-E multiple choice
    - iRAT on scantron
    - tRAT on IF-AT
    - Test is protected (not revealed or available outside of RAP)
- Prepared in folders
    - Blue "Individual" folder pre-loaded with 6 scantrons and 6 question books (even for teams of 5)
    - Red "Team" folder pre-loaded with 1 IF-AT and 1 appeal form
- Support during test: 2 TAs

- Process:
    1. Announcement (e.g. put away books and phones)
        - Hint: speak about why no phones; project a "no cell phone" graphic
    2. Distribute Individual folders
    3. Individual test: ~1 minute per question + 3 minutes (18-20 minutes)
    4. Students return Scantrons to Individual folder (team holds onto all question booklets)
    5. Trade Individual folders for Team folders
    6. Team test: same timing as Individual; 1 TA invigilates, 1 TA scores scantrons, I assist with sorting scantron forms while keeping an eye on the class
    7. Review individual performance (scantron report) once scoring is done and teams are working
    8. Teams hand in folder with IF-AT, 6 question booklets, appeal form
    9. TA counts question booklets to ensure 6 per team (automatic 0 on iRAT and tRAT otherwise… teams are warned and this is written right on the test!);
        - hint: rip the corners of question booklets as they are counted
    10. TA separates any used appeals forms and puts a fresh blank one back in the folder
    11. Based on iRAT performance (summarized by scanner software) I address any areas of concern
- Tips:
    - iRAT scores are lower than tRAT scores because the team outperforms its strongest members; also, if you use IF-ATs with a 4-2-1-0 scoring scheme, there are multiple chances for marks on a tRAT. I normally see 70-80% iRAT average, and 90-95% tRAT average
    - Remind students that the purpose of the RAP process is to get them ready, including providing you and them feedback on areas of strength and weakness; not a "test"
    - If you want to reuse questions (I suggest you do), you need to be firm:
        - Explain why you are being strict
        - Make sure no exam booklets leave the room (count booklets returned by team, as described above)
        - Make sure no one has a phone out or takes notes (automatic 0 and loss of IF-AT)
    - Look at the summary statistics (if you use a scanner to score the iRATs)
        - Consider mean score for each question; I aim for some a mix of easy (quick confidence-builders) and challenging (good for team discussion)
        - Consider discrimination index (or point biserial). It measures whether students who did well overall did well on a question. Scrutinize and revise questions where this is near 0 (no correlation) or negative (weak students on the test performed better on that question)

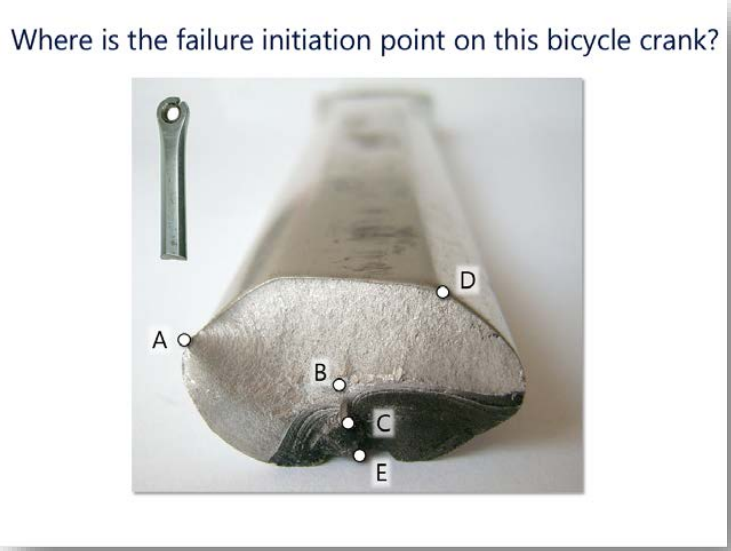
Examples questions are provided.

4S Application Tasks

Application tasks range from simple in-class multiple choice questions to large, complex out-of-class assignments.

Simple, in-class question 1.

This would be a short (5-minute) in-class activity. While coloured cards could be used here, I would often go for something like clickers or a particular pose or gesture (i.e. point in a specific direction for each letter) just to keep things moving quickly.



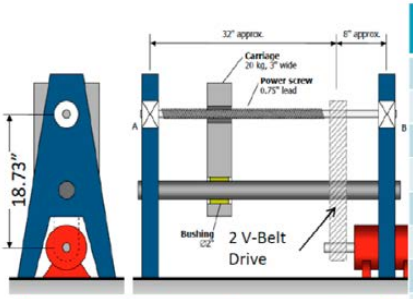
Simple in-class question 2.

Here's an example that builds off of the last. There are some subtleties for students where the thinking from the previous question does not apply here.

Hint: if you show of hands, coloured cards, or some other voting method, look for the team that reports their answer last or changes their answer and call on them first in the discussion.

Next page: an assignment example from a related course used with a gallery walk. It takes students several weeks to complete. By identifying a performance metric (in this case, cost), it is possible for teams to compare their project merit (after several weeks of work) with someone else's project. The reporting can also be done online (e.g. Google form), or low tech (see sticky note continuum example on next page), and then teams with the best design "on the hot seat" can show their solution on the doc cam for scrutiny with the goal for the class to identify the best design that meets all requirements.

Mech 325 Assignment 2 – Team B4

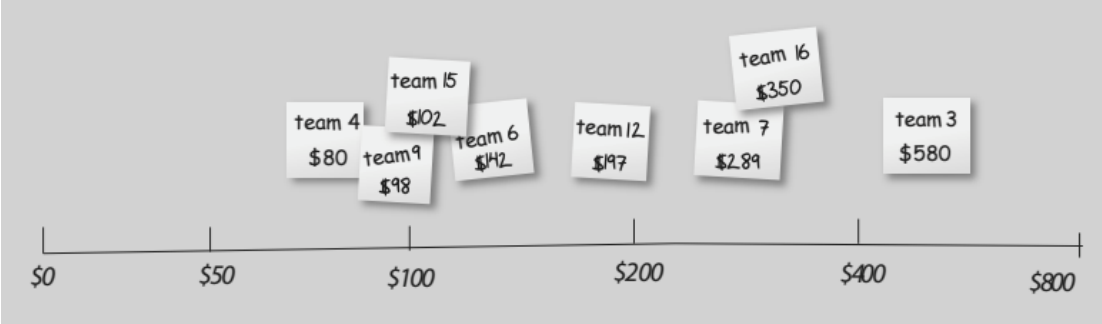


Component	Cost ($)
V-belt	$18.16
Pulleys	$33.50
Bearings (A and B)	$8.70
2" Dia. Bushing	$102.58

Assumptions
Coefficient of Friction for Belt = 0.51
Xo=0.02, a=3, b=1.483, θ=4.459

Component or Parameter	Value
Drive Train	e = 0.52
Drive Type	2 A50 V-belts, 6186K151
Drive Pulley (McMaster)	3" PD, 6245K32
Driven Pulley (McMaster)	5.75"PD, 6245K511
Center-to-center distance	18.73"
Expected Belt Life	201,790hr
Bearings A and B (Reid)	SKF-05 Deep Groove, Ball
I.D. / O.D. / Width	20mm / 47mm / 14mm
Dynamic Basic Load Rating	2860lb
Static Basic Load Rating	1470lb
Expected Bearing Life	8.75x10^11 revs
Bushing (McMaster)	PTFE-Fiberglass, Sleeve
I.D. / O.D. / Length	2" / 2.25" / 3"
Bushing Life	7861h (replace once)

Performance Metric = $162.94



Another Assignment Example

Included is an extended team assignment (on the redesign of an amusement park ride) that was peer assessed on peerScholar. It is a messy and ill-defined problem that forces students to make (and defend) many assumptions. The purpose here was less about the 4 Ss and in class discussion, but more about developing the skill of reviewing someone else's work and giving constructive feedback. It hit the S's of significant problem, same problem, and specific choice). In peerScholar, the assignment took place in three stages:

1. Teams worked together to interpret the problem and propose a solution. Each individual uploaded their team's solution to peerScholar.
2. In peerScholar, each individual was randomly assigned two other team's assignments to assess. They did this using 4 different criteria related to the appropriateness of the assumptions and analysis and the quality of the final design proposed.
3. In peerScholar, each individual was responsible for reviewing the feedback they received, discussing it with their team, and assessing the quality of the assessment they received.

MECH 326 Reading Guide

Module 1: Fracture

Overview

The readings outlined in this guide are intended to prepare a foundation of knowledge and skills that will be used in the MECH 326 classes and tutorials. You will have a short multiple choice Readiness Assurance Process (RAP) Quiz on this material. The quiz will primarily test your ability to recall this material; the emphasis is not to test your ability to apply or use the material (that will come later).

The readings are divided into three categories:

- ● **Required**: the primary source of material for the Readiness Assurance Process (RAP) Quiz. Each student is expected to complete the required readings.
- □ **Beneficial**: additional analyses, derivations, explanations and examples to provide in-depth understanding of the course material. These readings help develop a more complete understanding of course concepts necessary for the tutorials, exercises, exams, and design projects. It your choice whether or not you do the beneficial readings.
- \- **Supplementary**: good information for any mechanical designer to know. Useful for the course, but not part of tutorials or exams.

All readings are drawn from the course text: Budynas, R.G. and Nisbett, J.K., *Shigley's Mechanical Engineering Design*, McGraw-Hill. Section number references are to the 10th Edition. The 9th Edition sections are the same, with the exception that an additional section appears in 5-13.

Readings

Section		Title	Notes
●	5	-	A short introduction to the main topics of the chapter
●	5-1	Static strength	Additional information to help orient you to the purpose of the chapter topic
●	5-2	Stress concentration	Review material that is helpful information for the introduction to fracture mechanics section (5-12) and for later in the course.
□	5-3	Failure theories	A short overview of the various static failure theories; we won't be using these too much
-	5-4	Maximum-Shear-Stress Theory for Ductile Materials	One of two failure theories for ductile materials you should have seen before; we won't be using this too much

●/□	5-5	Distortion-Energy Theory for Ductile Materials	While technically not required for our work on fracture, this failure theory is important for other work in the course and so is required reading. (Example 5-1 is beneficial but not required)
-	5-6 to 5-11	Additional ductile and brittle failure theories	You are welcome to review this material, but it will not appear in the course
●	5-12	Introduction to Fracture Mechanics	This is the bulk of the material we will be using in MECH 326 and it consists of an introduction to the growth of cracks in mechanical elements.
-	5-13	Important Design Equations	A summary of the key equations presented in the chapter. Not bad to skim over, but most of the theories represented are not part of the assigned readings.

Sample MECH 326 RAP Quiz

1 Instructions

This test is closed-book. Electronic devices and aids must be put away. Standard exam policies apply.

Part 1: Individual – for each of the following questions, mark your response **in pencil** on the computer score card. When time is up, place your score cards in your individual folder and hold onto this booklet.

Part 2: Team – once you receive your team folder, work as a team and mark your responses by scratching the appropriate boxes on the IF-AT (scratch) cards.

Reveal a ★ in 1 scratch for 4 pts, 2 scratches for 2 pts, 3 scratches for 1 pt, 4 or 5 scratches 0 pts.

Record your total score and team name in the space at the top of the card. You can appeal any question using the included form. Place your IF-AT card, **all** exam booklets, and your appeal form in your team folder and hand it in. **You must return all booklets – your entire team will receive a score of zero on both the individual and team portions of the RAP quiz if any booklets are missing from the folder.**

2 RAP Quiz Questions

Choose the best response - a given question may have more than one choice that is correct but marks will only be given for the best answer.

1. **What is fracture toughness?**
   a) The area under the stress-strain curve for the material near a crack
   b) The local yield strength in the material at a crack tip
   c) The local fracture strength in the material at a crack tip
   d) The critical stress intensity factor
   e) The ratio of the critical stress intensity to the stress intensity factor

2. **In practice, the theoretical stress concentration factor, K_t, is often ignored (set to unity) under which condition(s)? (choose a single *best* response)**
   a) The material is ductile
   b) The material is brittle
   c) The material is ductile and the loading is cyclical
   d) The material is ductile and the loading is static
   e) The material is brittle and the loading is axial

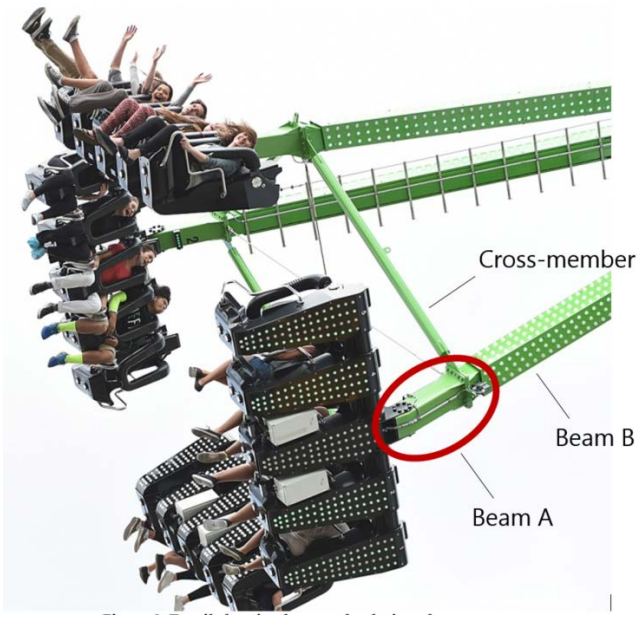
3. **The von Mises stress is given by $\sigma' = \frac{1}{\sqrt{2}}\sqrt{(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2}$. Why does shear stress not appear in this equation?**
   a) The expression above is based on principal stresses
   b) Shear stresses do not cause distortion of an element
   c) Shear stresses average to zero on a small element
   d) For cases where von Mises is used, only hydrostatic forces matter
   e) The σ' expression above is for normal stress only – there is a separate equation for τ'

MECH 326 Assignment Example (Abridged)

Scenario

With your newfound expertise in fracture mechanics, your team has been approached to assist with the preliminary redesign of a particular amusement park ride.[1] The ride is identical to "The Beast" at Playland at the PNE (see figure to the right). Up to 20 riders sit in chairs at the end of a long swinging and spinning pendulum.

The client is looking to change the aesthetic of the design by replacing Beam A (see lower figure) with the most slender beam possible. Your task is to recommend the beam cross-section and material that still achieves a safety factor of at least 10. The client is worried about the potential for fracture, so they like to know what type and size of crack they need to be able to identify in their visual inspections



The client indicates this is part of a larger feasibility study to look the viability of a redesign of the ride, but they do not have much in the way of specifications or details for you. They mention you should take a look at the videos of this ride online; otherwise, you have not been given a lot to work from in this project. They expect you to make and justify assumptions and approximations as you feel are appropriate.

Deliverable

Prepare a brief two-part report for the client to outline your work and your recommendation. Include a body suitable for a general engineering audience, and an appendix suitable for an expert audience. The body should not exceed three pages and should be suitable for engineers familiar with the basic concepts of mechanics of materials, but not necessarily the details found in MECH 326. Your appendix should provide sufficient analysis to support your design. Through peerScholar, you will assess other teams' designs and they will assess yours.

[1] Disclaimer: As much as I believe in all of you and know you will make great engineers, and as much as I'm doing my best to help you to learn fracture mechanics, if someone approaches you and asks you to design an amusement park ride, please say no for now – leave it to the experts!