



## Active Learning: Eight Models That Shape Instructional Practice

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# Active Learning: Eight Models That Shape Instructional Practice

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## Abstract

Developed since the mid-20<sup>th</sup> century, several instructional models have provided practical means to shift the emphasis in learning from lecture to engagement by students. The snapshots of models presented in this paper include *Cooperative Learning*, *Problem-Based Learning*, *Supplemental Instruction (SI)* (also *PALS*, *PASS*), *Team-Based Learning*, *Emerging Scholars Program (Mathematics Workshop)*, *Peer-Led Team Learning (PLTL)*, *Process Oriented Guided Inquiry Learning (POGIL)*, and *Learning Assistants*. These models have been well-disseminated, widely adopted, and incorporated in disciplines beyond their origins. For purposes of exploration and consideration of implementation, these “snapshots” provide an overview. Features of each model are presented, including the initial concern leading to the model’s development, level of introduction in the academic world, implementation overview, and who facilitates the students’ learning. Each model faces challenges in its adoption, often based on its foundational pillars, yet these models – as well as many others not explored here – have demonstrated that learning is based on experiences that encompass more than discipline-specific content.

Keywords: Active Learning, Instructional Models, Cooperative Learning, Problem-Based Learning, Supplemental Instruction (SI) (also PALS, PASS), Team-Based Learning, Emerging Scholars Program (Mathematics Workshop), Peer-Led Team Learning (PLTL), Process Oriented Guided Inquiry Learning (POGIL), Learning Assistants

### Introduction

Over the past several decades many instructional strategies have been developed, using “pedagogies of engagement” (Smith, et al., 2005), focused on engaging learners, both within the formal classroom structure and outside classroom walls. Some examples, as noted by Guskin and Marcy (2003), include learning communities, accelerated learning formats, intensive residencies, experiential and service learning, technology-based group and individual learning formats, and formalized methods of learning with peers. Active engagement in learning has been effective to promote retention, reduce withdrawals and failures and help students succeed to graduation, especially in STEM fields, as compared with the traditional method of lecturing (Freeman, et al., 2014). Comparisons with the lecture method as the baseline has been the traditional metric for assessment. Lecture, originating from reading from a precious book since the 15<sup>th</sup> Century (Felder, 2006), has been an effective means of transferring knowledge for only a fraction of learners. Knowledge acquisition is on the part of the learner, with guidance from experts, those who are more knowledgeable in an academic discipline. This guidance has provided an evolving change from lecture to active learning – pedagogies of engagement – dependent in part on instructors’ willingness, opportunity, and institutional rewards to reconsider how to engage students in learning.

To encourage instructors to consider changing their instructional methods, myriad materials have been published to encourage use of active learning methods, from classroom exercises to instructional interventions. For example, Woods (2014) proposes that over 30 variations of “different learning environments are available that empower students to take [...] process skills” (p. 5338) and “all these have a common feature: they start with a problem, they all empower students with parts if not all of the learning process, most include extensive peer interaction, they all have students actively engaged” (p. 5340). Other strategies are proposed, for example, by Miller and Tanner’s (2015) “list of commonly encountered terms” in Biology education. There are numerous options on how to teach to ensure that students are engaged in active learning. Choosing from so many diverse strategies takes intention, time, commitment, dedication, and effort.

The quest to close the gap between what is taught and what is learned is based on an admitted concern regarding the number of students who do not consistently persevere in formal education, especially in science, mathematics, engineering, and other disciplines, affecting their retention not only in those disciplines, but in higher education more generally.

Lecture has been the traditional teaching method at institutions of higher education. Talking may be augmented by writing on a Blackboard (or Whiteboard) or accompanied by PowerPoint slides. Engagement with students has included asking a question answerable

through the technology of clickers (to obtain percentages of right or wrong responses), depicted, for example, by Koretsky, et al. (2018), in an interview of an instructor's understanding of "active learning." The Socratic method – asking questions, encouraging responses – often fails as the number of students in classes increase; it is easy to hide in the back rows.

Over the past eight decades, recognizing and valuing students' perspectives and ways of thinking encouraged the development of methods of practice supported by theories of learning and social development. Active engagement methods have demonstrated increased retention in comparison to lecture as a method. Whether the instructor (teacher, faculty member, lecturer) or peer educator (student facilitator, peer leader, graduate student) facilitates the learning (during the class session; outside of the class session), whether the facilitators are formally or informally prepared for their role, whether students work on problems (through discovery, questioning, in roles), the models presented here share a deep appreciation of the importance of finding means to reach the learner. Each model has strengths and constraints, including how an institution (from colleagues to administration) provides means, and rewards the intentionality of supporting learning.

Eight formal instructional models for active learning in group work are presented: *Cooperative Learning*, *Problem-Based Learning*, *Supplemental Instruction (also PALS, PASS)*, *Team-Based Learning*, *Emerging Scholars Program (Mathematics Workshop, Math Excel)*, *Peer-Led Team Learning (PLTL)*, *Process Oriented Guided Inquiry Learning (POGIL)*, and *Learning Assistants (LA)*. These methods engage students in conversation and differ in the method of implementation. The order reflects their approximate chronological development. Each model's origins are presented, followed by method of implementation, facilitation of the method, and ending with challenges.

The models are concerned with students' learning, collaborating, and engagement through a variety of teamwork options. Differences include means of facilitation: by the instructor or peer undergraduate or graduate student; in classroom or outside session; training/preparation for facilitation; time spent preparing content or assessment; emphasis on broadening access to non-traditional students; tie-in to institution (such as a learning center).

Juxtaposing distinguishing features of each model has served to argue that the features are important (for example, Davidson, et al., 2014). When implementation is the goal, features must be foregrounded. How does one use a model? How should it be implemented?

Yet it is also important to look at shared features: these models encourage discussion, the voicing of how one thinks or understands, the struggle – and overcoming the embarrassment of "looking stupid" – in finding learning through mistakes, the necessary

teamwork in small groups (from pairs to larger groups), the realization among group members that each has something to contribute, the developing recognition of various paths in approaching problems, and the development of critical thinking (e.g., Quitadamo et al., 2009).

Comparing and contrasting models has been examined before. For example, Eberlein, et al. (2008) find common features among PBL, POGIL, and PLTL, starting with the framework of social constructivism, where the learner constructs the meaning of the imparted knowledge through social interactions. Several models have borrowed aspects of others. For example, Dolmans, et al. (2015) suggest combining PBL and TBL, and Lewis and Lewis (2005) combine POGIL with PLTL.

How can these models become more accepted as means of changing the emphasis in learning from lecture to engagement, to allow curiosity and enjoyment in intellectual and vocational pursuits? Linton et al. (2014) noted that studies of active learning have been “predominantly conducted in the classrooms of science education researchers who have had extensive experience and training in these techniques” (p. 243). Active learning, to “become more widely practiced, as recommended by Vision and Change (American Association for the Advancement of Science, 2011), need[s] to make it more accessible to all instructors” (p. 243).

To continue this path toward active learning and engagement, eight models are presented here.

- Cooperative learning
- Problem-Based Learning
- Supplemental Instruction (also PALS, PASS)
- Team-Based Learning
- Emerging Scholars Program (Mathematics Workshop)
- Peer-Led Team Learning (PLTL)
- Process Oriented Guided Inquiry Learning (POGIL)
- Learning Assistants

## COOPERATIVE LEARNING

### Origins

In the 1960s the U.S. education system was undergoing changes, especially in the aftermath of desegregation, integration of those with disabilities, concerns about students' levels of achievements, and development of science inquiry methodologies, while the dominant teaching method was lecture. Educators at various institutions met the challenge to ameliorate educational practices, beginning in primary levels, and over time, cooperative learning practices have been used in higher education. David Johnson and Roger Johnson are often cited as the "founders" of Cooperative Learning, yet many others also contributed (e.g., see Davidson, 2021).

Johnson and Johnson (2021) titled their method as "Learning Together and Alone." Their method of peer-to-peer interactions has five elements that are intended to promote:

1. Positive interdependence, in which students are committed to supporting every group member's success; as they encourage and support each other's effort to learn; even when students might encounter opposing viewpoints. From the perspective of the controversy theory, this allows students to reconceptualize and refine their conclusions;
2. Accountability by every group member for contributing their work to achieve the group's goals of accomplishing the assigned task;
3. Promoting interaction, whereby students interact to help, support, and encourage each other in their learning;
4. Developing the interpersonal and groupwork skills needed; and
5. Group reflection, when students discuss in their group to process both their achievements and their working relationship (see Johnson & Johnson, 1999 for fuller descriptions).

### Format/Implementation

#### *A. Forming teams*

Students are grouped by the instructor, and the number in the group varies depending on the activity. The group can be two, three, or four students. The group should be mixed in terms of level of ability to promote differing understandings and approaches to the activity, and if work on a task or project is expected to be done outside of class, teams may be formed by having blocks of time in common. Each group is formed for a specific

activity and ends with the conclusion of that activity (See Slavin, 1988 for discussion of team formation; Felder and Brent, 2007)

### B. *The Activity*

The same learning task, the cooperative activity, is provided to every group. The task is intended for group work and is both challenging and requires cooperation (Gillies, 2016). The group is expected to work together, by exchanging ideas and developing the “positive interdependence” which is fostered through the discussion and working on the task toward its conclusion. Roles may be assigned, such as group process manager, time-keeper, scribe, reporter, or other suitable roles for the given activity. Roles may be rotated over the course of an activity so that each student in a group has an opportunity to inhabit the role.

### C. *Sample Techniques*

Many well-known group strategies have been developed as part of the use of cooperative learning.

- *Think-Pair-Share*, one of the most used strategies of groupwork, encourages consideration of a problem; working with one other student, students discuss how to solve the designated problem (Lyman, 1981). The original included *listening* before the *Think* stage.
- *Peer editing*, where pairs of students review each other’s work and critique it to provide suggestions for improvement. Each student’s work is revised and is then submitted for grading by the instructor (Felder and Brent, 2007).
- *Jigsaw*, where each group is assigned part of a set of materials and the group members become “expert” in their assigned part. Each member of each expert group then shares their expertise with the other groups and then returns to their initial group with their new learning. Originally developed in early 1970’s, the steps for the Jigsaw technique are explained on the website (Aronson, 2025).
- *Round-robin*, where each student takes a step in solving a problem of several steps or providing information working with a sequential task.
- *Group investigations*, where groups work on one part of a research project, planning their investigation and presenting their findings.

Slavin (1980) provides multiple examples of strategies, including team tournaments.

### D. *Assessment*

Grading of students’ work is both on a group level and on an individual level. The instructor must announce grading policies on the first day of the class; a concern with

groupwork is that some students will work on the task/activity and others will not make an effort to participate or learn. Those who do not participate may be penalized by their team members who will ensure that the non-participant is not given credit for the group's product.

A role/function of one team member is to make sure that each person on the team participates, that every team member's questions and ideas are heard, and that each understands all aspects of the group's product and can discuss the work.

### Facilitation

Before the class session, the instructor formulates the learning objectives, and ways of measuring individual and group learning, and develops the activity or task.

New material is introduced at the beginning of a class session, then students work in groups on the activity or task. The instructor circulates among the student groups to observe and guide the groups' activities by noting:

- How are group members engaging in discussion and how well are they communicating, listening to each other, and commenting on each other's ideas?
- What social skills are used in students' interactions, in order to share ideas and resources, in the ways they act together, and find ways to reach agreement?
- Then, how do students reflect on both the progress on the activity and on their relationships, by exploring questions such as:
  - What has been achieved so far?
  - What still needs to be done?
  - How do we do this together?

The role of the instructor is an active director, who may need to facilitate and promote discussion and ways of working together, by asking open-ended questions, helping students develop trains of thought and build on others' ideas, to analyze them, develop strategies, and solve problems.

### Challenges

Developing teamwork skills may need explicit instructions, initially by each team designing its own rules and expectations, which is signed as a contract among the team members. Groups should stay together for some weeks, which inevitably will help the students find ways to deal with conflicts that arise in their work. A means to allow the group to voice differing views is to have regular opportunities for written reflection on what they each perceive is going well and where there are points of contention. They can share their reflections with

each other and discuss what is going well and where there is conflict. Listening to their teammates, without interruption, and paraphrasing what has been heard will augment consideration of views not their own and may allow for reconsideration of a position.

Resource: Cooperative Learning Institute, <https://www.co-operation.org/>

## **PROBLEM-BASED LEARNING (PBL)**

### Origins

A new medical school in Hamilton, Ontario, Canada, as part of McMaster University, was envisioned in the 1960's, which would organize learning into units organized by organ system, where biomedical and clinical problems would intersect. A suggested practice was that under the guidance of a tutor, groups of four to six students would discuss a presenting problem; other practices also were proposed and tried, often met with confusion. This led to experimenting with how to implement a non-traditional medical school curriculum. Howard Barrows contributed the idea of presenting students with realistic medical problems without prior curricular input (Loyens, et al., 2012) and as well as the idea of using actors who could be trained to act as patients in simulations. During the same period, a new medical school was developed in the city of Maastricht, in the Netherlands, and because students come out of high school into medical school, a more formalized program was developed (Servant-Miklos, et al, 2019). Concurrently medical schools were undergoing curricular reforms at Newcastle University in Australia, Michigan State University in the U.S., and others (Hung, et al., 2008). McMaster University developed a revised curriculum in the late 1970s that focused on clinical skills and individual and community-based problems.

The many disciplines that are brought together in diagnosing a medical patient have traditionally been taught separately in lecture format yet those entering the medical professions need to be able to analyze and synthesize a large amount of knowledge to properly treat a patient. In PBL, groups of students work together on “ill-structured problems (often interdisciplinary) and a tutor ... guides the learning process and conducts a thorough debriefing at the conclusion of the learning experience” (Savery, 2006, p. 12). From medical schools PBL began to be adapted in other disciplines in college courses in the 1980s, where open-ended problems, based on real-world situations, are presented to groups of students to solve together.

Problem-based learning has two fundamental postulates. The first is that learning through problem-solving is much more effective for creating in a student's mind a body of knowledge *usable* in the future than is traditional memory-based learning. The second is that the physician skills most important for patients are problem-solving skills, not memory skills (Barrows & Tamblyn, 1980, p. viii).

### Format/Implementation

Students work in small groups, often of four to six, for a period of time. They examine the problem, decide what information is needed for its solution, research information and discuss their findings, consider if the problem might have alternative solutions, and decide what the solution is.

A method that allows sharing of ideas is through visual record-keeping – on large paper or whiteboard, for example - which helps group members depict their information and developing knowledge. On the written surface, there are four columns each illustrate a category:

1. *Facts: information* that the students gleaned from the problem statement such as what the problem is and information on its occurrence;
2. *Ideas: hypotheses* keep track of evolving ideas about solutions;
3. *Learning Issues:* questions for further study;
4. *Action Plan:* plans for resolving the problem or obtaining additional information.

Hmelo-Silver (2004) notes that this fluid method allows students to discuss the progress of their work and change information as they examine options and ideas toward possible solutions.

Problems contain concepts across the curriculum so that learning is cumulative. The “ill-structured” problem might be presented as a scenario and promotes the generation of questions. It has many interrelated parts that necessitate finding information from multiple sources. Students will be able to evaluate the extent of their knowledge to generate options toward possible solutions and determine what they do not as yet know and how to determine the iteration of their research efforts. These tasks are guided by their discussion and collaborative sharing of their ideas and knowledge.

### Facilitation

In the original PBL health-care model setting, a facilitator works with one group of students and is called a tutor. The facilitator may be the course instructor who, in adopting PBL, moves from lecture to guiding through open-ended questioning. In such a situation, the instructor would facilitate the work of all groups in the classroom by moving around the room, observing discussions, and providing guidance through questions. Students may also serve as facilitators but must have preparation in supporting the work of groups (Hmelo-Silver, et al., 2019).

Challenges in facilitating PBL include (Hmelo-Silver, 2004):

- Ensuring the group members are all engaged and on task;

- Posing questions that both provide scaffolding and encourage discussion;
- Encouraging the recognition of what is known by members of the group;
- Acknowledging what is not known to find out necessary further information;
- Developing hypotheses based on evidence;
- Recognizing groups' differing dynamics of interactions: one group may work together smoothly, and another may involve conflicts that interfere with the group's functioning.

### Evaluation

Consolidating learning is accomplished by reflecting on what has been learned, both from working on the problem and each person's contribution and explicitly discussing what concepts and principles have been understood. Self-reflection, articulation on what has been learned, and discussion on group learning all promote metacognition and thoughtful consideration. Assessment of learning is formative and is carried out at designated intervals.

### Challenges

Students who are unfamiliar with active engagement in learning may need significant scaffolding before they are comfortable with discussing problems, looking for evidence to support their hypotheses, and working in collaboration with others in their group (de Graaff & Kolmos, 2003). Developmental and metacognitive learning may need to be considered and addressed on a consistent basis, with support gradually withdrawn (Hmelo-Silver, et al., 2019).

Not only students, but instructors, may need scaffolding in this method of learning. From developing appropriate materials to learning facilitation skills, instructors may need guidance and practice. Supporting students' learning demands a change in viewpoint, from authority dispensing knowledge to facilitating where guidance is subtle and developing deft actions and timing takes consideration and trial.

The issue of "content coverage" may arise in institutional discussion, leading to hybrid forms of PBL discussed below.

### Related Models (Savery, 2006)

#### *Project-based Learning*

Students work in teams to follow specifications toward an expected end product. Following procedures may include pre-determined "problems" that provide opportunities for

“teachable moments. Instructors provide guidance, suggestions, and continuous feedback to group members on completing the product.

#### *Case-based Learning*

Students prepare for the session with members of their group by reading the case problem and may be provided with background curricular materials. During the session(s) with their group members, they are expected to query each other’s understanding and when necessary, seek guidance from the facilitator.

An advantage of working with cases is to learn elements of the situation and problem, to develop preparation for dealing with similar problems in practice. A concern regarding this method is that learners do not set the objectives for the outcome of the situation, and they may not recognize a possible range of solutions in real situations.

#### *Inquiry-Based Learning*

Used especially in science education, learners are presented with an open-ended question or puzzling situation and must decide on possible solutions. Students can ask questions and expect answers from the instructor who provides information. Students develop hypotheses, gather data and evidence, process the information, and generate conclusions, which are evaluated as to their suitability. There is a reflective component on the processes undertaken, knowledge gathered, and efficacy of conclusions, as well as appreciation for knowledge gained.

Resource: <http://www.udel.edu/pbl/>

## **SUPPLEMENTAL INSTRUCTION (SI), PEER-ASSISTED LEARNING SESSION (PALS); PEER-ASSISTED STUDY SESSION (PASS)**

### Origins

The University of Kansas City (UKC) in Missouri was a private university founded in 1930, which admitted well-prepared students. In 1963 UKC was purchased by the University of Missouri system, and the now urban public institution was renamed University of Missouri Kansas City (UMKC). The UKC faculty expectations were confounded by a rise in attrition from one-fifth of the students to nearly half. This problem of retention was less about students' dropping out, discontinuing their studies, than it was a shift where students were not enrolled when their finances could not support their continuous enrollment.

A UMKC Retention Committee was formed in 1972 to address the issue of attrition. Faculty on the committee suggested that departmental budgets be augmented; administrators noted that funding tutoring and professional development for faculty had not changed the situation. To support and retain underprepared students in its professional schools of medicine, pharmacy, and dentistry, the focus on the professional and graduate level schools was intentional by the Retention Committee, which was concerned about its graduates, its most academically elite, and because there was community funding available. Gary Widmar, Chief Student Affairs Officer, hired Deanna Martin, a then-doctoral student in reading education, to pilot a supplementary model for a human anatomy class at the UMKC School of Dentistry. She worked with Robert Blanc, associate professor and curriculum specialist for the School of Medicine, who provided a framework based on a community health model, which focuses the intervention on the environment rather than on a deficit borne by individuals (Arendale, 2022; Arendale, 2002; Martin, et al., 1997).

The supplementary program was then implemented at the undergraduate level in 1981 after its successful results with the professional school students, which had demonstrated that an academic intervention supported health science students. The results provided credible results for the expansion to undergraduate courses (Arendale, 2022).

Originally called "Supplemental Course Instruction," the model's name gradually changed to "Supplemental Instruction (SI)." Outside of the United States, SI became known as "Peer-Assisted Learning (PAL)" in the U.K. This alternative name was used so as not to confuse "SI" with the role of professional tutors as used in the British higher educational system. In Australia, the program is known by the acronym PASS, "Peer Assisted Study Sessions (or Schemes)."

### Format/Implementation

The SI model targets courses considered “difficult” due to the high rate of failure (Arendale, 1994). These are often the initial courses in a discipline. “Difficult” courses may be characterized as having:

- expectations prior to class includes preparation by completing readings from textbooks and other materials;
- examinations that are cumulative, infrequent, and difficult (to “weed out” the “undeserving”);
- no overt expectation of attendance (unrecorded); and
- no expectation of interaction with other students or the instructor.

The SI model:

- is voluntary, and open to all students enrolled in the designated course;
- has regularly scheduled sessions;
- focuses on both study skills and course content;
- is led by an SI Leader, generally a peer student, who is trained to facilitate the sessions.

Assistance begins in the first week of the term. During the first class session, with the cooperation of the instructor, the SI Leader introduces the program and surveys the students to establish a schedule for the SI sessions. This timing allows students to gain support with study skills and understanding content before the first assessment. Study skills might include useful notetaking, ways of studying and preparing for class sessions, and preparing for taking exams. Content of the course material is used to practice the process of studying.

### Coordination of an SI Program

The SI program is usually housed in the campus Learning Assistance Center. The three prongs are the SI Supervisor, the SI Leaders, and the course Instructors (Hanssen et al. (2021; Arendale, 1994).

The SI Supervisor is a staff person who coordinates the campus SI program and is prepared for their role and its expectations through a formal professional development program of several days which has been developed by the UMKC SI Center. This program covers implementation of an SI program, management and supervision, study strategies, and assessment. The SI Supervisor identifies the courses considered difficult due to high rates of

failure and/or withdrawal, and coordinates with instructors. The SI Supervisor selects, hires, and supervises the SI Leaders, meeting with them regularly, as well as providing formal training sessions. Since SI is housed in the Learning Assistance Center, the program bridges academic affairs and student affairs, as noted by Hensen and Shelley (2003).

The SI Leader is a student who has successfully completed the targeted course. As part of their responsibilities, SI Leaders attend all class sessions of the relevant course for which they are leading SI sessions, so they are up to date with the course content. The SI Leader is expected to model good study strategies by taking notes and completing the assigned readings.

The SI Leader may meet with students more than once a week, and those meetings are predicated on when students signed up in the first-class session. The expectation of an SI Leader is that techniques of collaborative learning will be used to facilitate engagement among students in the group.

The Instructor for the course is expected to understand and support the SI model, so SI is only used in courses with a cooperating instructor. Even when administrators support the use of SI in certain courses, the cooperation of the Instructor is paramount. Support by the Instructor for the activities of the program may include ensuring that SI Leaders know the course material and are willing to meet with the SI Leaders to discuss SI sessions during instructors' office hours.

### Challenges

Since attendance by students is voluntary, students may choose not to attend or attend haphazardly, for example before an exam. This may preclude the formation of a group that works together over a semester. Emphasis on study skills, even with the use of course materials, may not promote deep understanding. The SI model may be modified depending on the type of course and need for mastery, which may incur more time.

Resource: <https://info.umkc.edu/si/>

## **TEAM-BASED LEARNING (TBL)**

### Origins

In 1979, Larry Michaelsen found that his Business course in Organizational Behavior at the University of Oklahoma no longer had an enrollment of 40 students but now numbered 120 students, due to university budget cuts. His teaching strategies had centered on using a Socratic dialogue method based in case studies, and he did not want to move to a lecture format. The deep discussions leading to problem-solving were important to learning. He decided to engage so many students by having them work in small groups, even with only one instructor.

Team-Based Learning is based on two premises: making students accountable, not anonymous, by working in groups and developing skills by working in teams; and coming to class sessions prepared to work. In class, students first complete a test individually and then compare their responses with their team members. This group discussion of the material takes the place of lecture. The initial framework was memorialized as the “4 S”: Significant Problem, the Same Problem, a Specific Choice, and a Simultaneous Report.

### Format/Implementation

Team-Based Learning (TBL) has four essential principles (Michaelsen, 2002; Michaelsen & Sweet, 2008; Roberson & Michaelsen, 2016):

1. Groups of five to seven students are formed by the instructor and work together for the duration of the course;
2. Students work both individually and together in their group, and are assessed on both;
3. Group assignments, which promote learning and team development, create a "product" that can be readily compared across teams;
4. Students must have frequent and timely feedback.

### *Group Formation*

Groups are formed at the beginning of the course by students responding to general questions, by a show of hands, to determine knowledge and experience. Sample questions might be: “Who has full-time work experience?”, “Who speaks a language other than English?” This is expected to yield a diverse mix of students (e.g., prior knowledge, demographic mix, etc.). Students are then asked to form a single line around the perimeter of the classroom grouped by the responses to the questions, with the least frequent responses at the front of

the line. Students then count off, by the number of groups to be formed divided by the total number of students (as determined by the instructor depending on the number of students to be assigned to each group). The “ones” form Group 1, and so on (Michaelsen, 2002).

#### *A. Individual Work*

Students are expected to study assigned material in advance of the class session, so they are prepared. In the class session, students are provided with an Individual Readiness Assessment Test (IRATS) to complete which tests their understanding; this is a multiple-choice test assessing the preparatory learning. The IRAT tests recall of the assigned material.

#### *B. Group Work*

The group takes the same test as a team, the Group Readiness Assurance Test (GRAT), and students discuss each response. Using an Immediate Feedback Assessment Technique (IF-AT) the group members work together on the answers until all of the answers are correct.

#### *Group Assignment – Application Exercises (“product”)*

Teams then work on problems based on real-world situations, that use the knowledge base that was assessed. All teams work on the same problem. The teams report their conclusions, through a voting system.

#### *Feedback*

Assessment is ongoing and built-in to the class session. In the group discussions of the team members, students become aware of what they do not understand. Students become aware of their mastery of their learning. When the group scores are compared, students may become motivated to pull together to include all members of their team. The open discussion in the groups is expected to engage all members of the group.

The results of the GRAT and IF-AT provide instructors with information on what students have not understood. This provides opportunities for follow-up questions and understanding of the material.

#### Developing the Course Content

Choosing the major concepts to focus on for course topics is the first step to designing the course objectives and preparing the Readiness Assessment Tests and the Application Exercises. The major concepts may focus on fewer than ten topics, drawn from the assigned reading materials (Michaelsen, 2002).

1. Time: How many class sessions will be devoted to the topic? Will there be attention to sub-topics?
2. Effective assignments: Promoting team (group) interaction provides challenges:
  - a. All groups work on the same problem;
  - b. The problem is based on a real-world issue pertinent to the course focus;
  - c. Group members must agree on the answer to the multiple-choice question (GRAT) and all groups report on their answer;
  - d. Groups may have chosen different solutions, and the groups must discuss their result;
  - e. The instructor mediates the discussion among teams.
3. Grading: After a designated number of sessions of practice, the grading occurs before going to the next topic.

TBL focuses on outcomes and performance (what students should learn) (Roberson & Michaelsen, 2016) by focusing on relevant learning activities, feedback, and self-assessment.

### Facilitation

The instructor facilitates the classroom sessions (Whitley, et al. 2015). Facilitation takes many forms, for example:

- Circulating among groups; students must be able to face each other;
- Observing issues in group discussions to promote dialogue;
- Monitoring time and setting time limits, even without explicit instructions;
- Acknowledging students' concerns;
- Expressing neutrality when asked to affirm or deny a response so that group discussion and processes are not affected;
- Asking open-ended questions;
- Summarize a group's discussion after observation;
- Promote reflection opportunities.

Group members also help facilitate by supporting their team members (Whitley, et al. 2015). This can include:

- Agreeing to set ground rules, such as no cell phones, engaging in activities that do not pertain to the task at hand;
- Providing feedback to other team members and listening to feedback from team members;

- Strategizing to consider alternative solutions;
- Discussing the activities and reaching consensus;
- Ensuring that all team members are involved and participating.

### Benefits

Students may gain professional skills by learning how to provide and receive constructive feedback, asking probing questions, and working in teams, as well as considering alternative solutions to a problem.

For instructors, TBL offers an opportunity for team-teaching to integrate content from various disciplines and possibly include clinical practices. This also may provide modeling of collaborative practices among authoritative figures (Burgess, et al., 2020).

TBL provides the experience of small group learning, facilitated by one instructor or a small group, in any course (Hrynchak & Batty, 2012). Thus TBL does not rely on institutional resources, only willingness by an instructor or team of instructors to change their in-class practices.

### Challenges

There is a great amount of effort required of the instructor or team of instructors to change from a lecture format to TBL. This may involve using a “flipped class” format which requires that students prepare for the class.

The design process to set up a TBL course demands time and thought. Steps include deciding on learning outcomes – possibly taking account content in subsequent courses – and materials for students to use prior to the class session; developing activities that support concepts; preparing the readiness assurance questions which will be used both individually and in the groups; and developing feedback mechanisms (Burgess, et al., 2020).

Expertise in the design process and developing facilitation skills may need institutional support through professional development (Hrynchak & Batty, 2012). There can be initial increases in workload which may not necessarily be recognized institutionally. Besides the course redesign, preparation of materials for the pre-class studying may be time-consuming: readings, videos, slide decks, problem sets. Preparing the readiness assurance questions and coding them may also be an ongoing task.

Resource: <https://www.teambasedlearning.org/>

## **EMERGING SCHOLARS PROGRAM (ESP) MATHEMATICS WORKSHOP, MATH EXCEL, CHEM EXCEL**

### Origins

Under the aegis of the academic Faculty Senate at the University of California, Berkeley, based on a proposal by Jerzy Neyman, a Mathematics Professor, the Professional Development Program (PDP) was established in 1964 to incubate programs to support student success. A focus on teaching calculus as a creative challenge was promoted, at the same time, by an interdisciplinary science and mathematics education graduate program (Asera, 2001). Uri Treisman, one of the graduate students in mathematics, in his Calculus recitation section observed that African-American students, some of whom he knew from a high school bridge program, did not perform well, while Chinese-American students did well. This observation led him, in 1975-1976, to match 20 students from each group, all of whom were enrolled in Calculus I. The two groups did not differ in regard to academic preparation, family support for higher education, motivation, or socio-economic status. The only difference between the two groups was the amount of social interaction: the African-American students studied alone, and the Chinese-American students studied together. The former group, socially isolated on a White campus, understood that “studying” meant working alone and socializing was a separate event. The latter group combined studying with socializing, reviewing their work together, added food and music, and included friends and older relatives who might stop by.

A PDP Mathematics Workshop was piloted in 1977 (Hsu, et al., 2008). It was a voluntary program which students attended for six hours a week to work in groups on calculus problems. The impetus for the PDP was to increase the number of students who passed Calculus with an A or B, became mathematics majors, and were from underrepresented groups. The pilot was expanded and in the 1980s the program was retitled the Emerging Scholars Program (ESP). With adaptations at other campuses, ESP was also known as MathExcel (Oregon State University) (Hake, et al., 2003) , and in other disciplines such as Chemistry, ChemExcel (University of Kentucky, where students came from a predominantly rural background, and which started with Math Excel (Duncan & Dick, 2000).

### Format

Traditionally, in a U.S. university - an institution with graduate programs - large undergraduate courses have regular “recitation” sections, led by a graduate student, which may each have up to 40 students and meet for 50 minutes two to three times a week. By

contrast, an ESP “workshop” section may have 12 to 20 students and meet for 75 to 120 minutes and is also led by a graduate student (Hsu, et al., 2008).

The workshop section meets outside of the course, and students choose those sections and are then expected to attend for the entire semester.

In the ESP Mathematics Workshop, student groups may start out with assigned peers; the groups may change over the course of the semester as students may move from one group to another. Students may work alone, then join a group, or work with at least one other student on the same problem.

Depending on the institutional and departmental decisions, ESP sections may meet more frequently than regular recitation sections, for longer periods of time, and rather than focus on homework problems, emphasis is placed on working in collaborative groups on challenging problems.

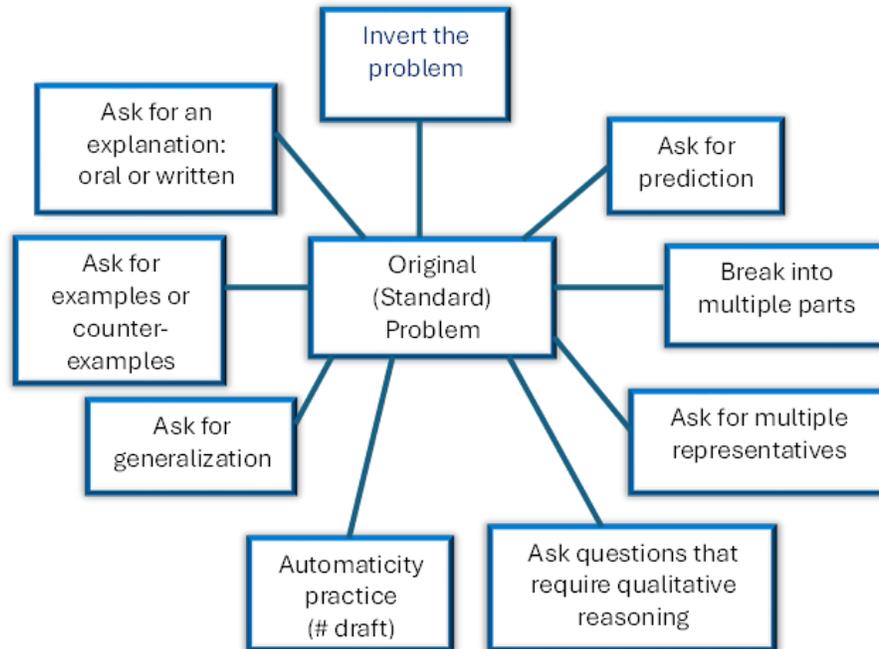
### Materials

Initially, Treisman examined the Calculus I curriculum to determine not only what were the main concepts that needed to be learned, but also which served as foundational for more advanced mathematics courses. A first group of mathematics graduate students, working with Treisman, designed calculus problems that were intentionally challenging and difficult to solve to encourage discussion. Some problems built on concepts from more than one prior unit of material that had already been presented in lecture, readings, and homework problems. Some problems were from exams from prior semesters. Over time, some campuses archived problems which could be re-used in subsequent semesters.

“Challenging problems” feature concepts from multiple topics previously presented, build on concepts that need further development, and necessitate discussion and collaboration. Building on solving a problem as a task, the Mathematics Task Enrichment Guide (see Figure 1) examines different strategies to solve the problem, making it a “rich task” (Epperson & Peterson, 2014).

### Facilitation

The graduate student facilitating the “workshop” session may have helpers, who may be graduate or undergraduate students. Students may work on problems individually or with others. The graduate student - called the graduate teaching assistant (GTA) – does not



**Figure 1.** Mathematical Task Enrichment Guide (Epperson & Peterson, 2014)

answer questions directly but poses questions to help students as they work on problems. The GTA moves around the room, observing what each student or group of students is working on (Hsu, et al., 2008).

The GTA is responsible for developing the worksheets with problems for each session and discusses these and students' questions with the course instructor. This helps to integrate the lecture and the work in the Workshop sessions.

Experience with facilitating Math Excel workshops provided benefits in a job search for an academic position (Frayer, n.d.)

### Coordinator

The position of Coordinator is necessitated when there is an ESP program at a campus. Where more than one class or course has a workshop session, administrative duties may include:

- Identifying and selecting GTAs which involves discussion with faculty and departmental staff who are familiar with graduate students;
- Recruiting students to participate in the workshops;
- Advising students on how to negotiate the campus culture, for example, with issues of financial aid and curricular issues;
- Developing administrative routines; and

- Coordinating social events to create a community, to help students connect to peers in the same majors and promoting a sense of comfort with the institution.

### Faculty

There is no change to the course lecture which the students are expected to attend. Faculty may choose to participate with the workshop program working with the GTAs and the Coordinator; and perhaps by visiting sessions and conversing with the participating students. Faculty may also derive professional benefits by participating in networks and organizations that promote the ESP program.

Some programs have developed training sessions for the GTAs, as well as professional development for faculty.

### Challenges

Students who enter college arrive with varying degrees of preparation, depending on where they previously were educated and what their social circumstances allowed. Programs to bridge knowledge and support gaps have been means to help students succeed in higher education.

The context of the original Emerging Scholars Program, at an elite university, with faculty and administrative support, has been duplicated with varying degrees of success and needs intentionality (Hake, et al., 2003). Variability among adaptations has precluded the formation of a network of similar institutional programs. However, there has been cross-campus collaboration in the sharing of problems, and GTA training at the University of Texas at Austin, where Uri Treisman brought the ESP after leaving the University of California at Berkeley.

## PEER-LED TEAM LEARNING (PLTL)

### Origins

Initially named Workshop Chemistry as a variation of Uri Treisman's Workshop Mathematics (Gosser et al, 2010), the addition of an undergraduate student facilitator, the "Peer Leader" was inspired by a comment of a colleague's wife (Dreyfuss, 2013). In the early 1990's, the model was at first focused on the development of challenging materials in chemistry in General Chemistry (Woodward, et al., 1993) at the City College of the City University of New York (CCNY, CUNY). Initial grants from the National Science Foundation (NSF) led to the dissemination of the model to other CUNY campuses. In a national effort to improve student performance in chemistry, Workshop Chemistry was one of five systemic initiative awards from NSF in 1995, and the leadership team now included Pratibha Varma-Nelson at St. Xavier University in Chicago and Jack Kampmeier at the University of Rochester, both organic chemists. The latter developed a collaboration with Vicki Roth, a learning specialist, who set the foundational tone for the selection and preparation of the peer leaders for this new role based on her background of Cooperative Learning and Supplemental Instruction.

The model was renamed in the late 1990's to the more descriptive *Peer-Led Team Learning* (PLTL) with the emphasis on the distinguishing characteristic of the facilitation of group work by a student peer. The renaming was necessary with the award of a National Dissemination grant in 1999 to include other science disciplines, mathematics, and engineering. Characterizing this new phase, materials were published by Prentice Hall (now Pearson), including a *Guidebook* (Gosser, et al, 2001), and a *Handbook for Team Leaders* (Roth, et al, 2001). Also, a system of seed money grants, the *Workshop Project Associate Awards*, provided an instructor with funds to pay Peer Leaders and develop materials, after attending an introductory workshop to the PLTL model and obtaining matching funds from their institution (Gafney & Varma-Nelson, 2008).

The PLTL model is characterized by six "Critical Components" formulated by Leo Gafney, the evaluator for the model's various phases, through his collection of performance and retention data, focus groups, and observations.

1. The Workshop is integral to the course;
2. Course professors are involved in the selection of materials, training and supervision of peer leaders, and they review the progress of Workshops;
3. Peer leaders are selected, trained and supervised to be skilled in group work as facilitators;
4. Workshop materials are appropriately challenging, directly related to tests,

- and designed for small group work;
5. The Workshops are held once a week for two hours, contain six to eight students per group, in space suitable for small-group activities;
  6. PLTL is supported by the department and the institution (Gosser et al., 2010).

### Format/Implementation

A weekly “workshop” session (other names are also used, e.g., seminar), led by a Peer Leader, is held outside of time in lecture (“class”). The number of students in a group works well with six to eight, but variations in campus implementations dictate the number assigned to a session, and groups may number twelve or more (numbers impact a Peer Leader’s ability to facilitate the session, and larger groups need experienced leaders).

The Peer Leaders meet with the instructor on a weekly basis to discuss the topics presented in lecture and the problems to be worked on in the workshop session. This weekly meeting is also an opportunity for instructors to obtain feedback on students’ understanding of the topics and where there was difficulty in solving problems.

The Peer Leaders are prepared for this role, either by a learning specialist (Tien et al. 2004), or instructor, or learning center staff. A key tenet is that they do not provide answers, focusing instead on the process of learning through questioning and other facilitation techniques (McWilliams et al, 2019).

Scheduling time for the session is easiest where the Workshop session is listed as a course component when students register for the course. Physical space for the sessions allows students to face each other and work in groups to discuss course materials and problems.

### Faculty

The role of the instructor does not change: Lecture is still expected; textbooks are used; tests are administered and graded. What changes is the expectation and need for alignment of the course topics with the materials to be worked on in Workshop. For this, the weekly meeting with the Peer Leaders is crucial.

Materials for the workshop may be prepared by the instructor: many prepare worksheets with problems for each session. These may also start with problems in the textbook, but as there may be an answer key, this is not ideal as students will tend to work individually by looking at the answer and “re-engineering” the problem to fit the answer. Workbooks were first published in chemistry by the Workshop Project in collaboration with Prentice Hall (now Pearson), and more recently by the Peer-Led Team Learning International Society (pltlis.org).

What may change to accommodate the workshop session is to change one lecture a week to allow time for the workshop. Instructors have found that this provides the opportunity for students to discuss and understand the topics. This may then change the structure of the lecture topics.

The term “faculty” has been used since the early days of Workshop Chemistry as the model focused on instructors to integrate workshop sessions with the lecture portion of the course. In the U.S. context, “faculty” has denoted discipline-specific tenured or tenure-track positions because of their standing in higher education. However, instructors at various levels have also implemented PLTL, although those in tenured positions may have allowed for the long-term continuity of the program in their course, department, or campus.

### Administration

#### *Compensation*

In the mid-1990s, one semester leading one workshop yielded a stipend of \$500 for a Peer Leader, a sum that was used as a benchmark across campuses. At the City College of New York, this amount was sufficient to pay for a semester’s tuition. At other institutions, state laws or other financial guidelines required payment by the hour – minimum wage – for student workers as temporary employees. More recently, minimum wage rates have risen, putting a strain on departmental and institutional budgets. Even maintaining the minimum stipend amount for a large program, e.g., 50 Peer Leaders for 600 students for two semesters, appears as a large expense.

Some institutions have shifted the cost of paying Peer Leaders to the budget of Learning Centers, have devised ways of funding income streams (Becvar & Saupe, 2021), or do not pay Peer Leaders, instead relying on the sense of community engendered by participating in the program (Alberte et al., 2013), compensated by letters of recommendation for graduate and professional studies.

#### *Selection and Preparation*

In starting a PLTL program in their course, faculty have chosen their best-performing students. Over time, Peer Leaders have been selected for their content knowledge, engagement with students, and often their desire to “pay it forward” for their gratitude in benefiting by successfully passing a course.

Where there are courses with large enrollment, often the gateway courses where many students perform poorly, over time a system of recruitment and selection is put in place. Sending letters to those students who received an A or B in the course and inviting them to apply; requesting recommendations from current Peer Leaders for those students who were

engaged in the workshop sessions and helped others; advertising for applications (flyers, word of mouth); and faculty recommendations have been used. Often, interviews of applicants are conducted, with experienced Peer Leaders included as interviewers.

While the term “training” of Peer Leaders has been used (see Critical Components), the dynamic nature of facilitating a workshop has suggested that the term “preparation” is more apt. A common feature with most programs is a pre-semester Orientation because the first Workshop of the semester/term may take place before the first class session and Peer Leaders need to know how to introduce the Workshop session as well as themselves to begin to create a team. At many campuses, first-time Peer Leaders participate in a formal course of one or two credits, to learn techniques of facilitation and learning theory (Tien, et al., 2004; Szteinberg, et al., 2020).

#### *Coordination*

Experienced Peer Leaders at many campuses are hired as coordinators, assigning Peer Leaders to faculty’s specific course sections depending on their schedules (as students), scheduling workshops sessions, finding rooms in which to hold workshops, ensuring that materials and supplies are available, Peer Leaders’ timesheets are submitted in a timely manner, and so on. Other campuses support these functions through staff at Learning Centers or in departments.

#### Benefits

The role of the student Peer Leader is an undervalued resource in higher education as the bridge to help students learn course material. Peer Leaders develop broad understanding of the many ways students think, deeper knowledge of course content, greater confidence, communication skills in facilitating students’ working together by using questioning techniques for example, as well as working with faculty as partners by providing feedback on students’ understanding of course material.

Faculty benefit by considering what materials will challenge discussion in workshop sessions, ensuring alignment with examinations, working with student Peer Leaders in obtaining feedback. Other benefits include improved student performance and interest in course content. Data collection can also lead to developing research interests in the scholarship of teaching and learning. Innovative studies have resulted, such as reflections on college learning experiences (Gafney & Varma-Nelson, 2007); and discourse analysis (Repice, et al., 2016; Dubey, et al., 2017). Long-term benefits include development of future faculty (Tien, et al., 2004) and alumni for the benefit of the institution.

### Challenges

Peer Leaders are undergraduates who have recently passed the course and demonstrated curiosity and leadership potential. Workshop Chemistry used second-semester chemistry students to peer-lead first semester chemistry. One campus (University of Rochester) initially used graduate students because recitation sections were used, and GAs were already available. The GAs did not have a good sense of how difficult first-year students found the materials, so generally undergraduate students serve as Peer Leaders.

Involvement of faculty is a strength of the PLTL model – ensuring that students learn the course content through discussion, problem-solving, and teamwork, by working with Peer Leaders. Yet recognition for improved performance and retention of students in courses and majors may lead to promotion and administrative roles; or attention to research interests may take away from involvement with the workshops.

Success and students' demands for more workshops in more courses moves the model away from an instructor and a few hand-picked Peer Leaders in a class, to an organizational structure with staffing, scheduling, and funding needs, and the need for greater coordination and budgetary demands on an institution's resources. Improved retention, more majors, and graduates may not match strategic demands.

Resource: Peer-Led Team Learning International Society, [www.pltlis.org](http://www.pltlis.org)

## PROCESS ORIENTED GUIDED INQUIRY LEARNING (POGIL)

### Origins

In the 1980s, faculty in chemistry (Ditzler & Ricci, 1995) at the College of the Holy Cross (Worcester, Massachusetts) developed an inquiry approach in laboratory work that followed the ideas of Michael R. Abraham and Michael Pavelich, set forth in their laboratory manual, *Inquiries in Chemistry*, first published in 1979. The focus in the teaching laboratory was changed from replicating previously developed experiments to the actions inherent in the process of scientific inquiry. Because science is based on the idea of discovery, students worked in groups to share their processes and findings. This approach at first was called “Discovery Chemistry,” then “Guided Inquiry” for the instructor’s role and the activities of the laboratory sessions to foster students’ discoveries. The “Process Orientation” is focuses on the importance of learning process skills (Apple, et al., 2016).

The goals of the POGIL approach are to support student learning by means of:

- Guided Inquiry: Supporting students’ construction of content to develop understanding;
- Process Orientation: Developing skills such as oral and written communication, critical thinking, problem-solving, and metacognition and assessment.

### Format/Implementations

In a POGIL session, students work in groups of three or four, generally in assigned roles which provide structure (Eberlein, et al., 2008). These roles may be Manager (responsible for ensuring that tasks are completed), Scribe (records the groups answers), Presenter (presents group answers to the class), and Reflector (observes and comments on group dynamics) or Technician (the only person allowed to operate a calculator).

The group’s activity unfolds in three phases – a learning cycle (Moog, et al., 2006; Moog & Spencer, 2008; Douglas & Chiu, 2013).

*Phase 1:* An "Exploration" phase in which a pattern is sought. Students generate hypotheses and test them in an attempt to explain or understand this information.

- a. Students are provided with the learning objectives for the activity, and the criteria for success (orientation section);
- b. The activity is designed to be the first introduction to the topic or specific content;
- c. Students explore information that describes aspects of a concept, perhaps a model (e.g., a graph, or a table of data), through a series of questions

(exploration). These questions help students develop an understanding of the concept by encouraging them to think critically about the model (this process is termed concept formation, or invention).

*Phase 2:* A "Concept Invention" or "Term Introduction" phase in which a concept is developed from patterns in the data and a new term is introduced to refer to these newly-identified trends or patterns. New terms are introduced at a point when the students have constructed their own understanding of the concept to which the term is then attached.

*Phase 3:* An "Application" phase in which the just-developed concept is applied in new situations. This phase is intended to generalize the concept's meaning and applicability, frequently requiring deductive reasoning skills.

- a. Students reinforce and extend their understanding of the concept by answering questions on exercises and solving in-depth problems (application).

*Reflection:* Students evaluate their learning by sharing the results of their group work with other groups in the class or the instructor, and reflect on their group performance.

Notably, students are not expected to have worked on any part of the activity prior to class meeting time, nor are they expected to do reading before class, since the learning cycle asks them to develop the ideas for themselves. After class they may do reading on their own. They also are given homework which allows them to practice using the concepts developed in class.

### Facilitation

The development of process skills — oral and written communication, information processing, teamwork, problem solving, metacognition, reflection — are explicit outcomes that are necessary to support the development of course concepts, and the instructor must facilitate both. The facilitation task is to guide by observing students' interactions and posing probing questions. This skill may include knowing when to leave a group alone, when to interrupt and what to say, encouraging discussion and use of the assigned roles (Douglas and Chiu, 2013).

The instructor does not lecture. In each class session, the instructor presents team assignments and roles. Teams usually work together for several sessions, and students' roles will change. A session will start with a summary of previous work, and an introduction of new work. As students work, the instructor may focus on particular students in a group and question their understanding. The instructor may interrupt all groups when it appears that some difficulty is affecting more than one group; groups' understanding will be discussed, and different approaches may surface regarding a concept.

The instructor monitors time and may stop groups' activity at certain times, which helps students to feel some pressure to respond to worksheet questions in a timely manner. The stopping moments may also provide opportunities to ask "clicker questions" to determine that students understand the material. Toward the end of the class session, summarization may be called for, either from groups or by the instructor. The session ends with a written reflection on their group's performance.

### Structures

The POGIL approach may be implemented in a variety of adaptations, depending on campus culture and factors such as instructor preferences, the size of the class enrollment, physical facilities. Such variations might include:

- Replacing lectures with POGIL sessions;
- Replacing one lecture each week with a POGIL session;
- Converting standard recitation sessions in a university setting to POGIL;
- Incorporating a POGIL activity as part of each class session.

### Challenges

Instructors may find it difficult to develop facilitation skills and expand these beyond the guidance of content materials to include supporting development of process skills. Measuring how successful students are in implementing process skills also may prove daunting. Preparation and intentional emphasis on particular process skills by means of a facilitation plan may help instructors focus each session.

The issue of "content coverage" on which instructors are often judged may prevent them from considering implementing POGIL. Proponents suggest that course concepts are mastered, sometimes with deeper understanding (Moog, et al., 2006).

Resource: POGIL- Process Oriented Guided Inquiry Learning, <http://pogil.org/>

## LEARNING ASSISTANTS (LA)

### Origins

As Otero explains (2022), she loved to learn, especially mathematics, and in high school as an Hispanic woman, was discouraged from pursuing her interests. Although a first-generation college student, with the help of mentors she discovered physics and physics education, and later, when she started working at the University of Colorado, Boulder, she initially worked in training teachers in physics. In 2001, for an undergraduate physics class, the Learning Assistant (LA) model was piloted as a collaboration between Drs. Valerie Otero (School of Education) and Dick McCray (Department of Astrophysics and Planetary Sciences).

The LA model has three characteristics:

1. Pedagogical Course - In their first semester as LAs, students participate (enroll) in a pedagogical course to learn about learning theory and practices, with an emphasis on inclusive practices.
  - a. Returning LAs – with at least one semester’s experience – may participate in formal meetings for further pedagogical development.
2. Planning Meetings - are held weekly, which involve the LAs, the course instructors, and possibly others connected with the LA program. The discussion focuses on the course content and how students are understanding the material.
3. Interactions between LAs and students – during scheduled class sessions, LAs work with groups of students by encouraging discussion of problems. The groups may be formed simply by where students sit.
  - a. LAs may also be tasked with working with students in settings beyond the class setting, such as scheduled office hours and group sessions. These may be in-person, virtual, or hybrid.

### Format/Implementation

As explained by Otero (2015), undergraduate students apply to serve as Learning Assistants and are selected by instructors. In some instances, LAs are guided by a graduate student. In some implementations they have previously taken the course; in others they participate in the course while also serving as an LA. In some implementations one LA works with 20 students, although in other instances, one LA works with ten students. During class sessions LAs circulate among their group of students and encourage discussion of problems. LAs help students develop and defend ideas, make connections between concepts, and solve

conceptual problems. LAs do not provide direct answers to questions or demonstrate how to work out a problem.

The use of the “flipped classroom” provides the “lecture” portion of the class as online homework assigned before the class session, so that class time is used for group discussion led by LAs.

#### *Pedagogical Course*

The training format is not prescribed, and may be held over consecutive days, or may be held in shorter segments over several weeks. The training may be guided by one instructor working with the LAs in one course or may be a formal program guided through a Campus Learning Center.

At least in their first semester serving as an LA, concurrent participation in the training course allows LAs to practice what they are learning pedagogically. In the training, LAs discuss scenarios, role-play, discuss what approaches have worked well, where they encountered struggles with student interactions, and reflect on how they might interact differently. They also discuss questioning strategies and issues of boundaries and ethical parameters. Pettit and Henderson (2024) lay out guidelines for training LAs in engineering that rely on Workshop Chemistry (PLTL) resources.

#### *Compensation*

In situations where LAs receive course credit as a technical elective toward their major, they may not be paid in the semester(s) taking the pedagogical course. In other cases, LAs may be compensated in pay or with a stipend for a workload of ten hours a week.

Returning LAs in some cases continue to participate in the “independent study” course or “special topics” course, and earn credits or no credits; in either case, the course is noted on the LA’s transcript, even if the elective credit is not counted toward their degree. Returning LAs may help facilitate training of new LAs and serve as a Team Leader for a particular course. In this latter role, they may receive a stipend or fellowship, depending on funding sources.

Where LAs are volunteers, they may not be tasked with grading because of Family Educational Rights and Privacy Act (FERPA) regulations.

#### Benefits

Learning Assistants, by discussing course content with students, may deepen their understanding of course concepts. Many LAs enjoy working with students and have a sense of “giving back” especially when they benefitted by having help from an LA while taking the course. Serving as an LA is recognized as useful in developing a professional portfolio of workplace skills, especially in communication, mentoring, and managing small groups.

For instructors, involving the LAs in discussions of revisions of course materials and methods of assessment may prove beneficial (Hill, et al., 2024) and reduce preparation time. Further, the focus in working with LAS may change their perspective on active learning and teamwork by students. Alzen, et al. (2018) note that the LA program provides a means to change views on teaching by working collaboratively with Learning Assistants.

### Challenges

Pettit & Henderson (2024) note that the “flipped classroom” may be more difficult to implement than expected, as some students need more guidance and explanation than is provided by online lectures. Deciding how much students need to “struggle” with content before they become discouraged and disengaged must be considered and monitored.

### Resources

University of Colorado Boulder Learning Assistant Alliance

<https://www.learningassistantalliance.org>

*Learning Assistant Model Implementation Guide*

<https://www.colorado.edu/program/learningassistant/la-model>

## References

### Introduction

- Davidson, N., Major, C. H., & Michaelsen, L. K. (2014). Small-group learning in higher education—cooperative, collaborative, problem-based, and team-based learning: An introduction by the guest editors. *Journal on Excellence in College Teaching*, 25(3&4), 1-6.
- Dolmans, D., Michaelsen, L., Van Merriënboer, J., & van der Vleuten, C. (2015). Should we choose between problem-based learning and team-based learning? No, combine the best of both worlds! *Medical Teacher*, 37(4), 354-359.  
<https://doi.org/10.3109/0142159X.2014.948828>
- Eberlein, T., Kampmeier, J., Minderhout, V., Moog, R.S., Platt, T., Varman-Nelson, P. & White, H.B. (2008). Pedagogies of engagement in science: A comparison of PBL, POGIL, and PLTL. *Biochemistry and molecular biology education*, 36, 4, 262-273. DOI 10.1002/bmb.20204
- Felder, R.M. (2006). Teaching engineering in the 21<sup>st</sup> century with a 12<sup>th</sup>-century model: How bright is that? *Chemical Engineering Education* 402, 2, 110-113.
- Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences USA*, 111, 23, 8410–8415. doi: 10.1073/pnas.1319030111
- Guskin, A. E. and Marcy, M.B. (2003). Dealing with the future now: Principles for creating a vital campus in a climate of restricted resources. *Change*, 35, 4, 10-21.  
<https://doi.org/10.1080/00091380309604106>
- Koretsky, M., Keeler, J., Ivanovitch, J., & Cao, Y. (2018). The role of pedagogical tools in active learning: a case for sense-making. *International Journal of STEM Education*, 5, 18  
<https://doi.org/10.1186/s40594-018-0116-5>
- Lewis, J. & Lewis, S. (2005). Departing from lectures: An evaluation of a Peer-Led Guided Inquiry Alternative. *Journal of Chemical Education*, 82, 1, 135-139.
- Linton, D.L., Farmer, J.K., & Peterson, E. (2014). Is Peer Interaction Necessary for Optimal Active Learning? *CBE—Life Sciences Education*, 13, 243–252. DOI: 10.1187/cbe.13-10-0201

- Miller, S., & Tanner, K.D. (2015). A portal into Biology education: An annotated list of commonly encountered terms. *CBE-Life Sciences Education*, 14, 1-14.  
DOI:10.1187/cbe.15-03-0065
- Quitadamo, I.J., Brahler, C.J., and Grouch, G. (2009). Peer Led Team Learning: A Potential Method for Increasing Critical Thinking in Advanced Undergraduate Science Courses. *Science Educator*, 18, 1, 29-39.
- Smith, K.A., Sheppard, S.D., Johnson, D.W., & Johnson, R.T. (2005). Pedagogies of engagement: Classroom-based practices. *Journal of Engineering Education*, 94, 1, 87-101.  
<https://doi.org/10.1002/j.2168-9830.2005.tb00831.x>
- Woods, D.R.. (2014). Problem-Oriented Learning, Problem-Based Learning, Problem-Based Synthesis, Process Oriented Guided Inquiry Learning, Peer-Led Team Learning, Model-Eliciting Activities, and Project-Based Learning: What Is Best for You? *Industrial & Engineering Chemistry Research*, 53, 5337–5354. dx.doi.org/10.1021/ie401202k
- Cooperative Learning
- Aronson, E. (2025). The Jigsaw Classroom. <https://www.jigsaw.org/>
- Davidson, N. (Ed.) (2021). *Pioneering Perspectives in Cooperative Learning: Theory, Research, and Classroom*. New York, NY: Routledge
- Felder, R.M., & Brent, R. (2007). Cooperative Learning (Chapter 4). In Mabrouk, P.A. (Ed.). *Active Learning: Models from the Analytical Sciences*, pp. 34–53., ACS Symposium Series 970. Washington, DC: American Chemical Society
- Gillies, R. M. (2016). Cooperative Learning: Review of Research and Practice. *Australian Journal of Teacher Education*, 41(3). <https://doi.org/10.14221/ajte.2016v41n3.3>
- Johnson, D.W., & Johnson, R.T. (2021). *Learning Together and Alone: The History of Our Involvement in Cooperative Learning*. Imprint Routledge.
- Johnson, D.W., & Johnson, R.T. (1999). Making Cooperative Learning Work. *Theory into Practice: Building Community through Cooperative Learning*, 38, 2, 67-73 (Spring).  
<https://www.jstor.org/stable/1477225>
- Lyman F.T. (1981). The Responsive Classroom Discussion: The Inclusion of All Students. In Anderson, A.S. (Ed.), *Mainstreaming Digest*, University of Maryland Press.  
<https://archive.org/details/mdu-univarch-027524/page/n117/mode/2up>

Slavin, R. (1980). Cooperative learning. *Review of Educational Research*, 50:315. DOI: 10.3102/00346543050002315

Slavin, R. (1988). Student team learning: An overview and practical guide (2<sup>nd</sup> Ed.). Washington, D.C.: National Education Association. <https://files.eric.ed.gov/fulltext/ED295910.pdf>

### Problem-Based Learning

Barrows, H.S, & Tamblyn, R.M. (1980). *Problem-Based Learning: An approach to medical education*. New York, NY: Springer Publishing Company.

De Graaff, E., & Kolmos, A. (2003). Characteristics of Problem-Based Learning. *International Journal of Engineering Education*, 19, 5, 657-662. <http://www.ijee.ie/articles/Vol19-5/IJEE1450.pdf>.

Hmelo-Silver, C.E. (2004). Problem-Based Learning: What and How Do Students Learn? *Educational Psychology Review*, 16 (3), 235-266.

Hmelo-Silver, C.E., Bridges, S.M., & McKeown, J.M. (2019). Facilitating Problem-Based Learning (Ch. 13). In Moallem, M., Hung, W., & Dabbagh, N. (Eds.). *The Wiley Handbook of Problem-Based Learning*, 297-319. <https://onlinelibrary.wiley.com/doi/abs/10.1002/9781119173243.ch13>

Hung, W., Jonassen, D. H., & Liu, R. (2008). Problem-based learning (Ch. 38). In Spector, M.J., Merrill, M.D., van Merriënboer, J. & Driscoll, M.P. (Eds.). *Handbook of research on educational communications and technology*, 485-506. New York, NY: Routledge.

Loyens, S., Kirschner, P. A., & Paas, F. (2012). Problem-based learning. In K. R. Harris, S. Graham, T. Urdan, A. Bus, S. Major, & H. L. Swanson (Eds.), *APA Educational Psychology Handbook* (Vol. 3). American Psychological Association. Downloaded from <https://ro.uow.edu.au/edupapers/1235>

Savery, J. R. (2006). Overview of Problem-based Learning: Definitions and Distinctions. *Interdisciplinary Journal of Problem-Based Learning*, 1(1). <https://doi.org/10.7771/1541-5015.1002>

Servant-Miklos, V.F.C., Norman, G.R. & Schmidt, H.G. (2019). A short intellectual history of Problem-Based Learning (Ch. 1). In Moallem, M. Hung, W., & Dabbagh, N. (Eds). *The Wiley Handbook of Problem-Based Learning*. Wiley-Blackwell. <https://doi.org/10.1002/9781119173243.ch1>

Supplemental Instruction

Arendale, D. R. (2022). *History of Supplemental Instruction-PASS: The first 25 years*.

Unpublished manuscript, Department of Curriculum and Instruction, University of Minnesota, Minneapolis, MN

Arendale, D.R. (2002). History of Supplemental Instruction (SI): Mainstreaming of Developmental Education (pp. 15-28). In Lundell, D.B., & Higbee, J.L. (Eds.). *Histories of Developmental Education*. Minneapolis, MN: Center for Research on Developmental Education and Urban Literacy, General College, University of Minnesota.

Arendale, D.R. (1994). Understanding the Supplemental Instruction model. *New Directions for Teaching and Learning*, 60. Jossey-Bass Publishers

Hanssen, T.E.S., Fromreide, N.K., & Mathisen, T.A. (2021). Supplemental Instruction at higher education institutions: A scoping review (Ch. 2). In Strommen-Bakhtiar, Helde, R., & Suzen, E. (Eds.). *Supplemental Instruction, Volume 3: Organization and Leadership*. New York, NY: Waxmann.

Hensen, K.A., & Shelley II, M.C. (2003). The Impact of Supplemental Instruction: Results From a Large, Public, Midwestern University. *Journal of College Student Development*, 44, 2, 250-259.

Martin, D.C., Arendale, D.R., & Blanc, R. (1997). Mainstreaming of Developmental Education: Supplemental Instruction© and Video-based Supplemental Instruction©. Kansas City, MO: National Center for Supplemental Instruction.

<https://conservancy.umn.edu/server/api/core/bitstreams/aea2ea02-af6c-4aee-9d8e-7d4c1d095ca7/content>

Team-Based Learning

Burgess, A., van Diggele, C., Roberts, C., & Mellis, C. (2020). Team-based learning: design, facilitation and participation. *BMC Medical Education* 20 (Suppl 2):461.

<https://doi.org/10.1186/s12909-020-02287-y>

Hrynychak, P. & Batty, H. (2012). The educational theory basis of team-based learning.

*Medical Teacher*, 34, 10, 796-901. <https://doi.org/10.3109/0142159X.2012.687120>

Michaelsen, L.K. & Sweet, M. (2008). The essential elements of Team-Based Learning (Ch. 1). *Team-Based Learning: Small-group learning's next big step*. *New Directions for Teaching and Learning*, 116. DOI: 10.1002/tl.330

Michaelsen, L.K. (2002). Getting Started with Team-based Learning.

<https://www.researchgate.net/publication/246322067>

Roberson, W.D., & Michaelsen, L.K. (2016). A compact introduction to Team-Based Learning.

<https://applied-science-cisdev.sites.olt.ubc.ca/files/2017/05/Roberson-Michaelsen-A-Compa>

Whitley, H.P., Bell, E., Eng, M., Fuentes, D.G., Helms, K.L., Maki, E.D., & Vyas, D. (2015). Practical Team-Based Learning from Planning to Implementation. *American Journal of Pharmaceutical Education*, 79, 10/Article 149.

### Emerging Scholars Program

Asera, R. (2001). *Calculus and community: A history of the Emerging Scholars Program: A Report of the National Task Force on Minority High Achievement*. New York, NY: The College Board. Online: <https://files.eric.ed.gov/fulltext/ED562582.pdf>

Duncan, H., & Dick, T. (2000). Collaborative workshops and student academic performance in Introductory college mathematics courses: A study of a Treisman model Math Excel program. *School Science and Mathematics*, 100, 7, 365-373. DOI:[10.1111/j.1949-8594.2000.tb18178.x](https://doi.org/10.1111/j.1949-8594.2000.tb18178.x)

Epperson, J., & Peterson, L. (2014). Using modified emerging Scholars Program concepts in professional development for tutors. *6th First Year Engineering Experience (FYEE) Conference August 7 – 8, 2014, College Station, TX, Session T4C*. <http://fyee.asee.org/FYEE2014/papers/1017.pdf>

Fraye, C. (n.d.). The search for an academic job in mathematics: The perspective of a UK graduate student. American Mathematical Society, <https://www.ams.org/learning-careers/employment-services/Fraye.pdf>

Hake, C.M., Crow, M.L., & Dick, T. (2003). Persistence in mathematics by underrepresented students: Experiences of a Math Excel program. *The Journal of Mathematics and Science: Collaborative Explorations*, 6, 87-101.

Hsu, E., Murphy, T.J., & Treisman, U. (2008). Supporting high achievement in introductory mathematics courses: What we have learned from 30 years of the Emerging Scholars Program. In M. Carlson & C. Rasmussen (Eds.), *Making the Connection: Research*

and Practice in Undergraduate Mathematics Education. Mathematical Association of America. <https://maa.org/wp-content/uploads/2024/10/NTE73.pdf>

### Peer-Led Team Learning

Alberte, J.L., Cruz, A., Rodriguez, N., Pitzer, T. (2013). Hub-n-Spokes: A model for centralized organization of PLTL at FIU. *Conference Proceedings of the Peer-Led Team Learning International Society*, May 17-19, 2012, New York City College of Technology of the City University of New York. <https://pltlis.org/wp-content/uploads/2012%20Proceedings/PDFs/Alberte-2-2012.pdf>

Becvar, J.E., & Saupe, G.B. (2021). DIY PLTL: Funding the Program of the Leaders by the Leaders. *Advances in Peer-Led Learning*, 1, 142-154. Online at <https://doi.org/10.54935/apll2021-01-12-142>

Dreyfuss, A.E. (2013). A History of Peer-Led Team Learning -1990-2012. *Conference Proceedings of the Peer-Led Team Learning International Society*, May 17-19, 2012, New York City College of Technology of the City University of New York. Online: <https://pltlis.org/wp-content/uploads/Dreyfuss-History-of-PLTL-2012.pdf>

Dubey, H., Sangwan, A. & Hansen, J.H.L. (2017). Using speech technology for quantifying behavioral characteristics in peer-led team learning sessions. *Computer Speech & Language*, 46, 343-366 <http://www.sciencedirect.com/science/article/pii/S0885230816303333>

Gafney, L. & Varma-Nelson, P. (2008). Peer-led team learning: Evaluation, dissemination, and institutionalization of a college level initiative. *Dordrecht*, The Netherlands: Springer. <https://link.springer.com/book/10.1007/978-1-4020-6186-8>

Gafney, L. & Varma-Nelson, P. (2007) Evaluating peer-led team learning: A study of long-term effects on former workshop leaders. *Journal of Chemical Education*, 84, 3, 535–539. <https://doi.org/10.1021/ed084p535>

Gosser, D.K., Kampmeier, J.A., & Varman-Nelson, P. (2010). Peer-Led Team Learning: 2008 James Flack Norris Award Address. *Journal of Chemical Education*, 87, 4, 374-380. <https://doi.org/10.1021/ed800132w>

Gosser, D., Cracolice, M., Kampmeier, J., Roth, V., Strozak, V., & Varma-Nelson, P. (2001). *Peer-led team learning: A guidebook*. Upper Saddle River, NJ: Prentice Hall.

- McWilliams, A., Dreyfuss, A.E., Becvar, J.E. (2019). *Facilitating Team-Based Learning: A Peer Leader's Guide to Leading Learning Activities*. El Paso, TX: PLTLIS Press:  
<https://shop.pltlis.org/index.php/product/facilitating-team-based-learning/>
- Repice, M.D., Sawyer, R.K., Hogrebe, M.C., Brown, P.L., Luesse, S.B., Gealy, D.J., & Frey, R.F. (2016). Talking through the problems: A study of discourse in peer-led small groups. *Chemistry Education Research and Practice*, 17, 3, 555-568.  
<https://pubs.rsc.org/en/content/articlelanding/2016/rp/c5rp00154d>
- Roth, V., Goldstein, E., & Marcus, G. (2001). *Peer-Led Team Learning: Handbook for Team Leaders*. Upper Saddle River, NJ: Prentice Hall.
- Szteinberg, G., Repice, M.D., Hendrick, C., Meyerink, S., & Frey, R.F. (2020). Peer leader reflections on promoting discussion in peer group-learning sessions: Reflective and practiced advice through collaborative annual peer-advice books. *CBE—Life Sciences Education* 19, 1, ar2, 1–13. <https://doi.org/10.1187/cbe.19-05-0091>
- Tien, L., Roth, V., Kampmeier, J. (2004) A course to prepare peer leaders to implement a student-assisted learning method. *Journal of Chemical Education*, 81, 1313-1321.  
<https://doi.org/10.1021/ed081p1313>
- Woodward, A., Gosser, D. & Weiner, M. (1993). Problem-solving workshops in general chemistry. *Journal of Chemical Education*, 70, 8, 651-665.  
<https://doi.org/10.1021/ed070p651.1>
- Process Guided Inquiry Based Learning*
- Apple, D., Ellis, W., & Hintze, D. (2016). 25 years of process education. *International Journal of Process Education*, 8, 1. <https://www.ijpe.online/2016/>
- Ditzler, M.A., & Ricci, R.W. (1995). Discovery Chemistry: A Laboratory-Based Approach to General Chemistry. *New Directions for Teaching and Learning*, 61, 35-43, Spring.  
<https://doi.org/10.1002/tl.37219956107>
- Douglas, E.P., & Chiu, C.C. (2013). Implementation of Process Oriented Guided Inquiry Learning (POGIL) in Engineering. *Advances in Engineering Education*, 3, 3.  
<https://advances.asee.org/wp-content/uploads/vol03/issue03/papers/aee-vol03-issue03-03.pdf>
- Eberlein, T., Kampmeier, J., Minderhout, V., Moog, R.S., Platt, T., Varman-Nelson, P. & White, H.B. (2008). Pedagogies of engagement in science: A comparison of PBL,

POGIL, and PLTL. *Biochemistry and molecular biology education*, 36, 4, 262-273. DOI 10.1002/bmb.20204.

Moog, R.S., Creegan, F.J., Hanson, D.M., Spencer, J.N., & Straumanis, A.R. (2006). Process-Oriented Guided Inquiry learning: POGil and the POGil Project. *Metropolitan Universities International Forum*. [muj > article > download > 20287 > 19880](#)

Moog, R.S. & Spencer, J.N. (2008). POGIL: An Overview (Ch. 1). Process Oriented Guided Inquiry Learning (POGIL). ACS Symposium Series 994. Washington, D.C.: American Chemical Society.

### Learning Assistants

Alzen, J.L., Langdon, L.S., & Otero, V.K. (2018). A logistic regression investigation of the relationship between the Learning Assistant model and failure rates in introductory STEM courses. *International Journal of STEM Education* 5, 56.

<https://doi.org/10.1186/s40594-018-0152-1>

Hill, C.J., Barrasso, A.P., & Spilios, K.E. (2024). The Influence of Learning Assistants on Faculty Use of Student-Centered Instruction. *Journal of College Science Teaching*, 53, 2, 154-161. <https://doi.org/10.1080/0047231X.2024.2316375>

Otero, V. K. (2015). Effective practices in preservice teacher education. In C. Sandifer & E. Brewe (Eds.), *Recruiting and educating future physics teachers: case studies and effective practices* (pp. 107–116). College Park, MD: American Physical Society.

Otero, V. (2022). Courage to learn: the unexpected physicist. University of Colorado (CU) Boulder School of Education: <https://www.youtube.com/watch?v=51vZav0hH0A>

Pettit, S.L., & Henderson, C.L. (2024). Development of Learning Assistants to improve student success. *Chemical Engineering Education*, 58, 1, 29-36. <https://doi.org/10.18260/2-1-370.660-132217>