

POGIL Learning Cycle as a Model for Active Learning

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Introduction

The types of active learning strategies implemented in college classrooms are varied. Determining which active learning strategies fit your teaching philosophy and learning goals for your students involves researching available strategies and trying them. After investigating the myriad of evidence-based teaching practices reported in the last several years, we settled on Process Oriented Guided Inquiry Learning (POGIL) as the student-centered teaching strategy to implement in introductory chemistry courses for the following reasons:

- POGIL is a research-based pedagogy that is well established in undergraduate chemistry courses (Simonson, 2019).
- Published materials are available in general chemistry (Wiley and Flinn Scientific).
- Professional development opportunities are available through regional workshops, national conferences (National Conference for Advanced POGIL Practitioners), and writer's retreats.

Theoretical Framework

POGIL activities are based on a learning cycle model (Figure 5.1) that is consistent with the constructivist theory of learning: the idea that knowledge and understanding must be constructed in the mind of each individual learner. Additionally, the format of POGIL activities builds meaningful learning: Ideas learned meaningfully are interconnected within the cognitive structure of the learner and are memorable and recallable. Karplus and Their (1967) were the originators of this learning cycle model as a teaching strategy for elementary school science. Research by Abraham and Renner (1986) further demonstrated that a learning cycle sequence of exploration, then invention, then discovery is optimal for developing content knowledge.

The Guided Inquiry Learning (GIL) aspect of POGIL is based on a learning cycle of exploration, concept invention, and application phases (Figure 5.1) and forms the foundation for the in-class activities that learners use to guide them to construct new knowledge.

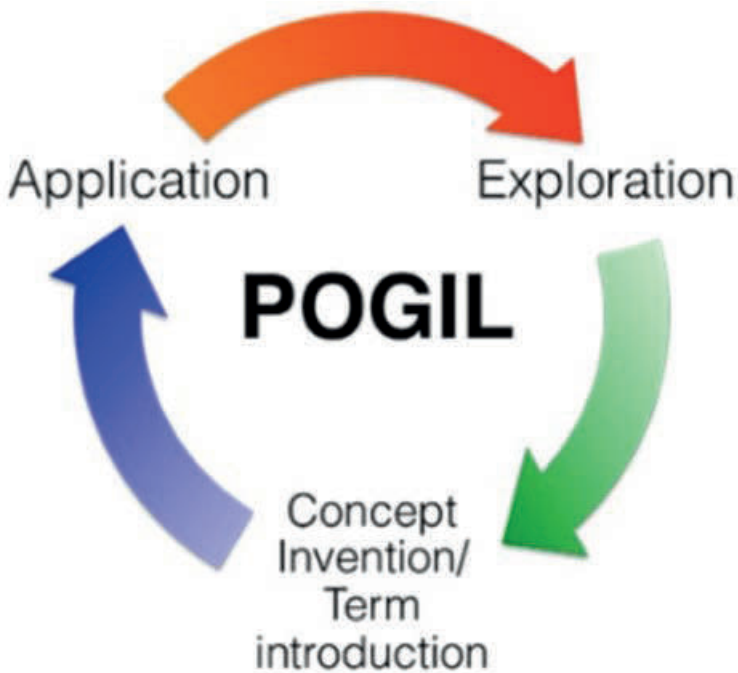


Figure 5.1. POGIL learning cycle.

Bauer, Daubemire, and Minderhout (as cited in Simonson, 2019, p. 9) describe the learning cycle steps as follows:

During the exploration phase, students examine a model, which can be data, a figure, text, or other suitable material. The model is a critical feature of a POGIL activity and is carefully crafted. The model is interrogated using specially designed (guiding) questions to direct students' attention to the salient features of the model and may include questions that prompt recall of relevant prior knowledge. The student team discusses responses to the questions, and their conversations lead them to recognize a relationship or pattern in the information provided in the model and to link that with prior knowledge. The questions and model combine so that students recognize and "invent" the idea that is the focus of the learning cycle activity. Once the concept is invented, the standard name of the concept is provided. The POGIL activity concludes with an application segment in which questions are posed that apply the newly learned concept to new contexts.

The POGIL classroom structure also incorporates Vygotsky's idea that constructing knowledge and gaining understanding happen in a sociocultural context (Newman & Holzman, 1993). Classrooms designed to incorporate communication between peers or between instructor and learners is a critical component of developing understanding. Cooperative learning is fundamental to the implementation of POGIL. Students work in small teams of three or four

students and hold individual roles to ensure that all students are fully engaged in the learning process.

Benefits of POGIL

The POGIL pedagogy has been validated in a variety of educational settings (high schools, two-year and four-year institutions) and in a variety of science, technology, engineering, and mathematics (STEM) disciplines (chemistry, biology, clinical and health sciences, engineering, mathematics, and computer science) over the last 20 years (Simonson, 2019). The benefits include helping students better grasp the concepts of the discipline, improve student success, and prepare students for the workforce.

National reports published by the American Association for the Advancement of Science (2009), National Research Council (2012), and the ABET Engineering Accreditation Commission (2016), for example, discuss the importance of students graduating from college ready for the workforce in skills such as problem-solving, management, creative thinking, leadership, communication, teamwork, and learning how to learn. An important aspect of POGIL activities is the development of process skills. Learners cultivate essential professional skills such as communication, critical thinking, information processing, management, problem-solving, and teamwork as they work through each POGIL activity.

Lo and Mendez (as cited in Simonson, 2019) completed a literature review of 43 studies selected based on their criteria of POGIL being identified as the intervention method in the study and as the primary data aimed to demonstrate potential efficacy of POGIL. The data collected was broadly categorized as performance or survey data. Performance data included exam scores, quizzes, or questions from these summative assessments, grade distributions for courses, and pass/fail rates. Survey data pertained to the student's experience or effect on motivation/interest. The results from the survey data showed a positive (79%) or neutral effect (19%) from the POGIL method. The results from the performance studies (pretest vs. posttest scores, grade point average [GPA], course grades, and completion rates) demonstrated that students in POGIL courses had higher GPAs by 0.57 on a four-point scale and a 14% higher completion rate, on average (Simonson, 2019).

POGIL Implementation in Introductory Chemistry Courses at UNC Charlotte

Why POGIL?

The first semester of transitioning from lecture-based instruction to student-centered instruction involved trying a few different active learning strategies. What emerged from these trials was that some techniques were met by students more favorably than others. Many active learning strategies require students to obtain foundational material on their own before it is discussed in class. Students must watch a video or read the textbook to learn some of the basic terms and concepts before they use them in class activities. Students in introductory chemistry

courses often struggle with the language and information presented in written or graphical format. Asking students to read or watch a video before knowing the terms or thinking about the concepts is often confusing to them. Yet these are skills that students must develop to continue to learn beyond the classroom environment.

POGIL is designed to have students learn terms and develop concepts through guided inquiry activities during class, as previously described. Students are introduced to the topic and construct knowledge of the underlying principles in class, and then practice applying this new knowledge before they are asked to read the textbook or see further explanations. The concept invention/term introduction and application phases of the POGIL learning cycle allow students to gain the fundamental knowledge and apply it before leaving class. This approach gives students the opportunity to ask questions for clarification as they are learning the material for the first time. Then, when they read the explanations in the textbook or watch videos that present more complex information or problems, they have a basic understanding of the key terms and concepts.

Instructional Time

The instructor's role in a POGIL classroom is a facilitator of learning instead of a deliverer of content. The instructor circulates throughout the classroom and observes teams as they interact and attempt to answer the guided inquiry questions. The instructor intervenes only as needed, which may occur when teams need clarification or to further guide their thinking toward a comprehensive response. The instructor controls the classroom flow in that they must decide when teams need to continue working to grasp a key concept or when a whole class discussion is required to ensure the class is practicing scientific reasoning in their explanations as they present to their peer teams. There may be moments when the instructor decides that a brief lecture presentation to the entire class is needed if a majority of students are not grasping the important underlying concepts being developed in the POGIL activity.

The student's role in a POGIL classroom is to actively engage in the topics for the day by reading, thinking, writing, and discussing with their peers the guided inquiry questions in the activity and to develop a team consensus to gain conceptual understanding. Students may be asked to present to the class their team's response to a key question in the activity. Students are doing the cognitive lifting for a majority of the class period.

Team Assignments and Roles

Forming teams that foster contributions from all team members effectively and equitably is necessary for collaborative learning environments. It is not an easy task to get introductory-level college students to work together toward a shared goal of learning. The educational literature provides ample discussions of how to form effective teams and can be used for guidance. Teams of three were formed in the implementation of POGIL in introductory chemistry courses. Each team was designed to have a range of academic ability, but not too large of a range, and with an awareness of diversity and inclusion issues. For example, teams in which an underrepresented student is isolated as the lone representative in the group were avoided. The

first team assignments were made based on limited information about each student, as they were made right after the add/drop deadline. Academic abilities were determined based on results from the prerequisite quiz given at the end of the first week of class. Academic behaviors that foster student success are not established until about a month into the course. For these reasons, and to address conflicts that have occurred between team members, new teams are assigned about halfway through the course.

A true POGIL practitioner will assign each student in the team a role. Roles are designed to ensure the team works effectively, and all members contribute as they help each other construct new knowledge. Common roles assigned in POGIL settings are manager, recorder, presenter, and reflector, or a similar variation. The manager keeps the team working collaboratively and makes sure everyone is participating and staying on task. The recorder writes the consensus response developed by the team on the activity worksheet, or as designated by the instructor, which may be collected or used by the presenter. The presenter reports the team's findings to the class. The presenter is responsible for articulating the team's response and its reasoning as to how they determined their response in oral or written form to the class. The reflector observes interactions among team members and provides feedback to the team on what they are doing well and where they need to improve. The reflector role is a challenging role for younger students, as it requires the ability to contribute to the learning activity and to how the team is interacting.

The primary roles we have used in introductory chemistry courses are a reader and recorder. The reader helps get the team started on each set of questions in the activity by reading the information and question out loud. The reader serves as a facilitator of the team's discussion by asking others for a response or rebuttal to another student's response. The recorder is responsible for writing the team's response to the key questions as designated by the instructor.

Peer-Assisted Leaders

The implementation of POGIL as an instructional strategy in larger enrollment courses (more than 50 students) requires additional facilitators beyond the instructor to be present. We have incorporated peer-assisted leaders (PALs) into the interactive classroom to provide the additional support needed. PALs are undergraduate students who successfully completed the course recently. They help facilitate discussion among teams and field questions from the teams as students work through the activities. PALs are trained as learning facilitators during a weekly meeting led by the instructor. Topics discussed during this weekly meeting were centered around how to get students to work together as a team and group dynamics, as well as the POGIL activity and its content. Some PALs also held weekly review sessions for students to attend to get extra help outside of class. The PAL-led review sessions, like traditional supplemental instruction sessions, were available through a partnership with the University Center for Academic Excellence (UCAE). The UCAE trained the PALs for their review sessions at a biweekly meeting.

Outside of Class Time

Students are assigned readings from their textbook that correspond to the activity completed in class immediately following the class meeting and before the next class. In addition, three to five traditional textbook problems are assigned as homework to further practice the key concepts discovered in the most recent activity completed. Instructor-written problem sets are assigned at the end of a chapter to give students the opportunity to practice the topics for a given chapter in a comprehensive way. Students can request examples from the assigned homework be worked by the instructor in the weekly problem session or through a video posted in Canvas. Weekly assessments are given to ensure students receive additional feedback on their learning gains.

Challenges

Implementing active learning strategies in introductory chemistry courses presents a few challenges. Students new to actively participating in their learning during class are initially resistant. Most students expect to sit quietly and take notes during class as the instructor presents information to them, since this scenario is the typical setting found in high school and college classrooms. A student may be asked an occasional question about the information being presented, but often they do not have to answer the question at all, or they do not need to answer the question out loud to anyone else in the class (they may answer through use of personal response systems, for example). Many students are not used to a social constructivist approach to learning. Asking students to answer questions in a collaborative team setting makes some students disengage. They fear being wrong in front of their peers, they may be shy, or they may lack a personal stake in the team's progress, to name a few reasons why students choose to not engage with their group members. There are strategies an instructor can use to help students understand the benefits of collaborative group learning to try to get students to buy in to the approach. The instructor can insist that team members follow their respective roles and provide explicit instructions on teamwork on cue cards for students to follow. In large lecture settings, it is especially challenging to enforce all of the team roles and to make sure the roles rotate among team members, so all members have the opportunity to experience each role and see their value in team contributions.

It is also difficult to train the PALs adequately. PALs are just beyond novices themselves in terms of content knowledge. They do not always recognize legitimate answers from students if the concept is explained in a different way from how they know it, nor do they know how to adjust misguided thinking from a team in some situations. Training PALs takes additional time by the instructor as well as additional resources.

An additional challenge is keeping a large number of teams working through an activity at approximately the same pace. Some teams work through the activity quickly while others struggle through the questions and take longer. One technique used to keep teams moving forward at about the same pace is to use a personal response system to have occasional check-in points in the activity where teams must ensure they are to a certain point in the activity when

the check-in question is posed. Having additional application problems for students to practice after completing the activity is another method used to ensure faster-paced teams are still engaged in the activity topics.

Summary

POGIL is a pedagogy based on cognitive science and educational research in which students collaborate by working in teams on carefully designed activities. The learning cycle on which POGIL activities are based involves exploring a model and answering guided inquiry questions that lead students to discover the underlying concept of the topic. Students then apply their new knowledge gained to new situations, which reinforce the concepts.

References

- Abraham, M. R., & Renner, J. W. (1986). The sequence of learning cycle activities in high school chemistry. *Journal of research in Science teaching*, 23(2), 121-143. <https://doi.org/10.1002/tea.3660230205>
- ABET Engineering Accreditation Commission. (2016). *Criteria for accrediting engineering programs, 2016–2017*. Retrieved from <https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2016-2017/>
- Association for the Advancement of Science. (2019). *Vision and change in undergraduate biology education: A call to action*. Retrieved from <http://visionandchange.org/finalreport/>
- Bauer, C. F., Daubenmire, P. L., & Minderhout, V. (2019). Not just a good idea, POGIL has a theoretical foundation. In S. R. Simonson (Ed.), *POGIL: An introduction to process oriented guided inquiry learning for those who wish to empower learners* (pp. 3–22). Sterling, VA: Stylus Publishing LLC.
- Karplus, R., & Their, H. D. (1967). *New trends in curriculum and instruction*. Chicago, IL: Rand McNally & Co.
- Lo, S. M., & Mendez, J. I. (2019). Learning—The evidence. In S. R. Simonson (Ed.), *POGIL: An introduction to process oriented guided inquiry learning for those who wish to empower learners* (pp. 85–110). Sterling, VA: Stylus Publishing LLC.
- National Research Council. (2012). *Education for life and work: Developing transferable knowledge and skills in the 21st century*. Retrieved from <https://doi.org/10.17226/13398>
- Newman, F., & Holzman, L. (1993). *Lev Vygotsky: Revolutionary scientist*. London, England: Routledge.
- Simonson, S. R. (2019). *POGIL: An introduction to process oriented guided inquiry learning for those who wish to empower learners*. Sterling, VA: Stylus Publishing LLC.