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# A Collaborative International Active Learning Workshop for Engineering Education in India – An Experience Report

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## Abstract

This experience report describes a 4-day international workshop, a collaborative effort by American and Indian engineering educators, conducted at a large University in India. Two American engineering educators and one Indian engineering educator collaborated to devise a workshop that focused on research-based engineering education excellence, specifically aimed at introducing evidence based pedagogies to engineering educators from all over India. We chose two pedagogical approaches that have shown to improve student learning in engineering classrooms in the United States of America. Peer Instruction (PI) is an active teaching-learning pedagogy in which students actively participate in their learning through pre-class preparation, Conceptual Questions posed by the instructor, individual responses using clickers or an online portal or flashcards or manual raising of hands or a handheld student response system device, students then discuss their answers with a fellow student and obtain the revised response. The Process Oriented Guided Inquiry Based Learning-Like (POGIL-Like) pedagogical approach utilizes a structured student group model with well-defined student roles, where students co-construct knowledge through carefully crafted Models and Activities. These models and activities are designed to facilitate one or more Explore-Invent-Apply (E-I-A) cycles in learning during the class session. While PI and POGIL-Like have been shown to improve student learning outcomes in engineering disciplines in America, they are yet to be adopted in a widespread fashion in India. The primary goals of this 4 day workshop were: 1) to introduce PI and POGIL-Like to engineering and science educators in India, specifically to University faculty members, 2) help them identify sections of courses they teach at their Universities that could be taught using PI and POGIL-Like, and 3) assist them in developing classroom materials for both pedagogies in their respective disciplines, that they could take back with them and implement in their courses. There were a total of 22 participants in the workshop, who were faculty members belonging to various disciplines ranging from Computer Science to Metallurgical Engineering. We surveyed our participants before and after the workshop to gauge their initial understanding of active learning techniques (Pre-survey) and their comfort level with PI and POGIL-Like at the end of the workshop (post-survey). During the workshop we conducted several sessions on active learning using PI and POGIL-Like including small-group and individual activities for participants to develop PI and POGIL-Like course materials for the courses that they teach. A comparison of our pre- and post- survey responses indicated that the faculty who participated in our workshop enjoyed the workshop and learned how to get started on introducing PI and POGIL-Like in their classrooms in the near future. Our workshop sessions were conducted in the PI and POGIL-Like format, where participants engaged in peer discussions and E-I-A cycles. Participants also discussed what they foresaw as potential challenges during the adoption of these pedagogies.

## Introduction

Peer Instruction (PI) is a small group pedagogical approach centered around active learning with roots in Physics, which the computing education community has begun to adopt over the last few years [1]. In PI, active student engagement through small group discussions is the focus, where students are engaged in discussing and answering short answer and multiple-choice questions, real-time during a class session. This is facilitated by the use of student response systems in class, which provide real-time student feedback to the instructor [2].

POGIL-like is centered around the core tenets of POGIL [3] [4]. No prior information given to students (which is the exact opposite of a flipped classroom), and carefully crafted “models” and “activities”. POGIL-like utilizes “learning cycles”, and activity questions are crafted based on the Explore-Invent-Apply cycle combined with Directed/Convergent/Divergent question types, all aimed at encouraging students to leverage the collective knowledge of the group. These approaches, based on social constructivist concepts, have been well studied in STEM disciplines, and relatively recently in CS, in America. While PI and POGIL-Like have been shown to improve student learning outcomes in engineering disciplines in America, they are yet to be adopted in a widespread fashion in India.

In this experience report, we describe a 4-day international workshop, a collaborative effort by American and Indian engineering educators, conducted at a large University in India. Two American engineering educators and one Indian engineering educator collaborated to devise a workshop that focused on research-based engineering education excellence, specifically aimed at introducing evidence-based pedagogies to engineering educators from all over India. The primary goals of this 4 day workshop were: 1) to introduce PI and POGIL-Like to engineering and science educators in India, specifically to University faculty members, 2) help them identify sections of courses they teach at their Universities that could be taught using PI and POGIL-Like, and 3) assist them in developing classroom materials for both pedagogies in their respective disciplines, that they could take back with them and implement in their courses.

The rest of the paper is organized as follows. Section II describes the related literature. Section III details the implementation of the workshop. Section IV presents the results of the surveys conducted in the workshop, as well as an analysis of our findings. Section V presents possible threats to the validity of our study. Section VI delineates possible future work and Section VII concludes this paper. Appendix A provides the complete session details and agenda of the workshop, Appendix B delineates a sample handout for Day 1 of the workshop, and Appendix C contains the pre- and post- workshop survey questions administered to the participants of the workshop.

## Related Literature

This experience report focuses on three distinct topics: active learning in engineering education, PI in Engineering; and POGIL in Engineering. As such, prior literature pertaining to both topics in the context of teaching engineering disciplines, with an international focus, is explored in this section.

*Active Learning in Engineering Education*

Using classroom observations, faculty interviews, student surveys, and focus groups, Shekhar and Borrego [5] examined an engineering instructor's postworkshop implementation of active learning in an electrical engineering course. The findings demonstrate the influence of faculty conceptions of teaching in the selection and design of activities and the subsequent impact of these design choices on student engagement. The authors report the instructor's and students' responses to the active learning exercises and present recommendations for engineering faculty development.

Asok et al.[6] demonstrated the strategies to achieve higher order thinking skills (HOTS) through various ALE strategies like Role Play, Jigsaw, Brainstorming, debate, Mind map etc for Concept Understanding and Group assignments, combined mini projects, Discussion on Topics, Quiz, and Puzzles for Concept Applying. They applied various learning strategies and assessed the student outcomes. They reported that HOTS is achieved by developing applications or products, with improved interpersonal skills and lifelong learning skills. The evidence for the effectiveness of active learning environments among engineering students is shown by great improvement in their academic result, placement record and research interests.

Hernández-de-Menéndez et al [7] described a case from their experience with Active Learning techniques in specified areas of engineering education at Tecnologico de Monterrey. Results indicated that this approach supports the development of in-demand competencies such as Teamwork, Problem-solving and Analysis. In addition, students' performance and retention rates were improved.

The informal network 'Active Learning in Engineering Education' (ALE) has been promoting Active Learning since 2001. ALE creates opportunities for practitioners and researchers of engineering education to collaboratively learn how to foster learning of engineering students. The activities in ALE are centered on the vision that learners construct their knowledge based on meaningful activities and knowledge. In 2014, the steering committee of the ALE network reinforced the need to discuss the meaning of Active Learning and that was the basis for this proposal for a special issue. More than 40 submissions were reviewed by the European Journal of Engineering Education community and this theme ended up with eight contributions, which are different both in their research and Active Learning approaches. These different Active Learning approaches are aligned with the different approaches that can be increasingly found in indexed journals [8].

*PI in Engineering*

PI is fast becoming a popular active learning, student centric pedagogy in CS education. PI was developed by Mazur [1] and originally adopted in Physics classrooms. PI has been utilized heavily in the hard science disciplines over the last three decades and is now gaining widespread acceptance in engineering disciplines including CS and Computer Engineering (CE). Several pilot and replication studies have established the effectiveness of PI as the pedagogy of choice for teaching CS courses. Utilizing PI, several studies have been conducted in CS; chief among them being the pioneering studies by Porter, Cutts and Simon [9-11]. How students learn from discussions resulting from in-class multiple choice questions and the extent to which this learning manifests on a final exam have been studied in several introductory CS courses [12-13], thus correlating the increase in in-class correctness due to PI to the single final exam to find statistically significant relationships. PI has been utilized in teaching introductory level CS classes as well as cybersecurity [14].

PI has been successfully employed in engineering classrooms for several years. Nicol and Boyle [15] describe a study in which first year Engineering Mechanics students were taught using two variations of PI – the Mazur approach [1] and the PERG approach [16]. Schmidt [17] studied the teaching of engineering dynamics using PI supported by clickers, for an engineering dynamics course with students across 9 different countries. Bartelt-Hunt et al. [18] evaluated the use of PI in 2 civil engineering courses-a required junior level course, a senior/graduate elective course – both in classroom courses. In software engineering (SE), the body of work by Esper [19], Adawi [20], and Gopal and Cooper [21-24] has laid the foundation for implementing PI in undergraduate SE classrooms. Gopal and Cooper also specifically examined possible relationships between in-class student answer correctness, and quiz and exam performance in an undergraduate software engineering course [23]. Herman and Azad [25] compared PI and collaborative learning in an undergraduate computer architecture course. Their findings suggested that PI improved student learning efficiency, saving students time, and reducing student stress, in addition to increasing their sense of belonging. While several studies exist regarding PI in Engineering in America and other countries, prior literature on PI in India is sparse. This is one of the main reasons that we embarked on conducting this workshop to introduce PI as a formal pedagogy for the Indian engineering classroom.

*POGIL in Engineering*

POGIL has been used extensively in the US in domains like Chemistry [26], and in Materials Science and Engineering [27] and Computer Science [28]. POGIL employs the guided inquiry approach to develop students' understanding in a three-stage manner: exploration, concept invention/formation and application [29].

Walker and Warfa [30] meta-analyzed twenty-one studies (n = 21) in STEM disciplines involving 7876 students that compared POGIL to standard lecture conditions. Their study found that based on conventional measures of class performance, POGIL had a small effect on achievement outcomes (effect size = 0.29, [95% CI = 0.15±0.43]) but substantially improved the odds of passing a class (odds ratio = 2.02, [95% CI: 1.45±2.83]). That is, participants in the POGIL pedagogy had higher odds of passing a course and roughly performed 0.3 standard deviations higher on achievement measures than participants in standard lectures. In relative risk terms, POGIL reduced the risk of failing a course by 38%. These findings suggest providing opportunities to improve process skills during class instruction does not inhibit content learning but enhances conventional success measures [30]. Other notable studies regarding POGIL in engineering include the ones by Saltibus [31] in an Engineering Materials Technology course, Phillips [32] in undergraduate mechanical engineering courses, Aedi and Masitoh [33] for Informatics Engineering, and Gopal [34-36] in software engineering.

In the Indian context, the work with POGIL at VNR VJIET, the engineering college and VJIM, the management school had very positive experiences of having improved student grades and process skills in a first year engineering course with 540 students [37]. According to the authors, POGIL helped to create high levels of critical thinking and problem solving and helped in conceptual clarity, student engagement, communication through cooperation and reflection. Working in teams made students imbibe qualities like patience, valuing other's thoughts, better listening and improved creative thinking. This inquiry-based team environment energized students and provides instructors with instant and constant feedback about what their students understand and misunderstand [37]. The teachers in the study also reported enjoyment in their new roles as facilitators.

Another POGIL study in India by Malliga et al. [38] in undergraduate civil engineering classrooms comparing POGIL and traditional lecture, indicated notable distinctions in how the two groups perceive their respective learning outcomes, as well as insights into the differences, similarities, and relationships between various groups. Lotlikar and Wagh [39] measured the impact of POGIL on overall performance of students. The results indicate that students who were taught Design Patterns using POGIL performed better thereby improving their programming skills, critical thinking, problem-solving as well as communication skills. It also resulted in much better concentration level and leads to guided thinking in arriving towards a solution. To the best of our knowledge, this is the first reported study on applying and evaluating the impact of POGIL to teach design patterns.

## Workshop design and elements

### *Workshop Goals*

While POGIL is a proprietary term, we utilize a slightly modified version of POGIL called POGIL-Like for our workshop. POGIL-Like is identical to POGIL but lacks the official scrutiny that the POGIL Consortium requires to certify a set of activities as POGIL [40]. Hence, we use the term POGIL-Like throughout our experience report to denote the pedagogical approach involving Process Oriented elements that focus on Guided Inquiry.

We set out to achieve the following well thought-out goals in this workshop. The primary goals of this 4-day workshop were as follows.
1) Introduce PI and POGIL-Like to engineering and science educators in India, specifically to University faculty members.
2) Help faculty identify sections of courses they teach at their Universities that could be taught using PI and POGIL-Like.
3) Assist them in developing classroom materials for both pedagogies in their respective disciplines, that they could take back with them and implement in their courses.
4) Identify impediments to implementation of PI and POGIL-Like in engineering classrooms in India

### *Participants*

There was a total of 22 participants in the workshop, who were faculty members belonging to various disciplines such as Computer Science, Engineering Design, Chemistry, Electrical Engineering, Networking and Communications, Computational Intelligence, Mechanical

Engineering, Computing Technologies, Data Science and Business Systems, Metallurgical and Materials Engineering. These faculty members taught courses including Machine learning, Artificial intelligence, Computer Organization, Digital Image Processing, Data mining and analytics, Production of iron, Production of steel, Introduction to Robotics, Field and Service Robotics, Introduction to Motion Planning, Data structures, Data analytics, Fourier Series and Number theory, Differential Equations, Linear Algebra and Calculus, Data Structures, Computer Architecture, Machine Learning, Deep Learning, Theory of Computation, Reinforcement Learning, Molecular Biology, Genetic Engineering, Calculus, Linear Algebra, Complex Variables, Differential Equations, Numerical Analysis, Advanced Mathematical Methods, Mathematical Modelling, Programming for problem solving, Java Programming, and Database Management Systems.

*Workshop organization*

The workshop was divided into 3 segments: PI, Cloud based tools, and POGIL-Like. The first two days of the workshop focused on PI. We conducted sessions on introducing Active Learning concepts to our participants through mini lectures and handouts. Each day of the workshop was split into several sessions, each lasting 1.5 hours. The agenda for the entire workshop can be found in Appendix A.

PI was taught in a real time PI classroom with the workshop participants functioning as students in the PI classroom. The intent was to teach the participants how PI was implemented in the classroom while allowing them to learn the basic concepts surrounding the pedagogy, simultaneously picking out and learning how to develop PI based class sessions for a portion of the courses they teach. Thus, in the workshop classroom, during the first two days, the "students" were faculty members who were participants; the topic taught was PI, and the pedagogy used was PI to accomplish teaching and learning of the topic of PI.

The final two days of the workshop focused on the concepts behind POGIL-Like, and how to implement it in the classroom. Again, this was accomplished by allowing participants to function as students in a POGIL-Like classroom. We followed the classic POGIL-Like implementation pattern and provided participants with handouts containing POGIL-Like Models and Activities. Participants selected and identified a portion of the courses they teach, and developed POGIL-Like models and activities for the same. Again, in the workshop classroom, during the last two days, the "students" were faculty members who were participants; the topic taught was POGIL-Like; and the pedagogy used was POGIL-Like to accomplish teaching and learning of the topic of POGIL-Like.

The entirety of the workshop was conducted using in person classroom format where mini lectures were conducted in combination with PollEverywhere [41] and Google Classroom [42]. Participant pre and post surveys, handouts for each session, and artifacts produced as a result of the lab exercises, were all administered on and collected within the Google classroom set up. Separate folders were provided for each participant where they uploaded each session's completed work.

*Overall format of the workshop*

The overall format of the workshop can be summarized in the following steps:

1) Participants complete a pre workshop survey.
2) Participants engage in two days of PI related sessions. As part of these sessions, they select a topic in one of the courses they typically teach, and learn how to conduct PI in their classroom for the chosen topic. All elements of what PI is and how it can be implemented in the class, along with guidance on helping them develop PI materials for the topic, are provided. At the end of the PI workshop days, participants have developed PI materials on the chosen topic and are potentially ready to walk into their classrooms and implement PI for the chosen topic.
3) Participants engage in two days of POGIL-Like related sessions. As part of these sessions, they select a topic in one of the courses they typically teach, and learn how to conduct POGIL-Like in their classroom for the chosen topic. All elements of POGIL-Like and how it can be implemented in the class, along with guidance on helping them develop POGIL-Like materials for the topic, are provided. At the end of the POGIL-Like workshop days, participants have developed POGIL-Like materials on the chosen topic and are potentially ready to walk into their classrooms and implement POGIL-Like for the chosen topic.
4) Participants complete a post workshop survey.

*Pre- and post-workshop survey details*

We surveyed our participants before and after the workshop to gauge their initial understanding of active learning techniques (Pre-survey) and their comfort level with PI and POGIL-Like at the end of the workshop (Post-survey). Both surveys had the same questions posed in the same order. We designed the surveys to help us gauge the level of familiarity of the participants with active learning in general, and PI and POGIL in particular. They also enabled us understand how much the participants learned from the workshop, what aspects of the workshop they found beneficial, and what could use improvement. There were questions that probed participants' understanding of small group pedagogies and how students learn individually and in groups. There were also questions about how instructors can recognize misconceptions in students. There were 30 questions in the pre survey and post survey each. During the workshop we conducted several sessions on active learning using PI and POGIL-Like including small-group and individual activities for participants to develop PI and POGIL-Like course materials for the courses that they teach. A comparison of our pre- and post- survey responses indicated that the faculty who participated in our workshop enjoyed the workshop and learned how to get started on introducing PI and POGIL-Like in their classrooms in the near future. Our workshop sessions were conducted in the PI and POGIL-Like format, where participants engaged in peer discussions and E-I-A cycles. Participants also discussed what they foresaw as potential challenges during the adoption of these pedagogies. The questions that we formulated for the pre- and post- survey can be found in Appendix B.

*Handouts and artifacts*

We created handouts for each session. Handouts were provided on Google Classroom, and participants worked on the handouts as part of the lab exercises during the workshop. Both PI and POGIL-Like formats allow room for hands-on activities and exercises. Each day of the workshop included appropriate handouts for each session. A sample handout for Day 1 can be found in Appendix B.

## Classroom implementation of PI and PI question development

We utilized PI in the classroom to teach our participants about PI. Our workshop participants were the equivalent of participants in the classroom, and the workshop facilitator served as the instructor. Our classroom implementation of PI followed the steps outlined by Porter et al. [9], and Gopal and Cooper [21]. The sequence of steps we followed consisted of preparatory readings as part of the flipped classroom approach. These readings were assigned to participants to be completed before the class session. During class, mini lecture sessions were interspersed with participants actively engaged with multiple choice questions designed to help them confront and explore challenging concepts [21]. Participants used the online student response system through iClicker [28] to record their real time responses. Participants answered twice, with an initial vote before peer discussion, and a final vote after a 2-3-minute discussion with small peer discussion groups of 3 participants each. After the final vote the instructor, who is the author of this paper, held a short class-wide discussion, at the end of which the correct answer to the clicker question was clearly indicated to the entire class.

PI utilizes isomorphic questions [9]. The development of PI questions involved multiple steps.
Step 1:  Participants identified where students had common misconceptions in the topic they chose to develop PI materials for.
Step 2:  Participants determined the number of questions they wished to include in each class session, based on the typical length of a PI cycle in class [1].
Step 3: In accordance with the flipped classroom approach [1] for PI, the third step was to decide what material needed to be assigned to students for familiarization prior to class, and what material would be based on the mini-lectures.
Step 4: Participants created meaningful multiple choice distractors and one correct solution for each question.

Participants were instructed to ensure that each question had one single correct answer, but that the questions encouraged participants to think beyond obvious answer choices. We also ensured that the PI questions spurred participants to discuss possible answer choices by making distractors realistic.  Our goal was to formulate questions that required participants to engage at the higher levels of Bloom's taxonomy, where they synthesize and analyze allied concepts to answer the given question, and not simply recall from memory [29].

## Classroom implementation of POGIL-Like and POGIL-Like question development

### *During the workshop sessions*

We used POGIL-Like to teach our participants about POGIL-Like pedagogy. Identical to PI, our workshop participants were the equivalent of students in the classroom, and the workshop facilitator served as the instructor. POGIL-like activities in small groups (4-6 students) (30 minutes): Participants were assigned to small groups and participated in activities crafted to guide them through the exploration of challenging concepts [28]. Participants participated in a

POGIL-like cycle for each topic, shared their understanding and reasoning with each other, and learned the topic, while recording salient concepts that they learned. At the end of each class: Report- out with instructor led discussion (5-10 minutes): The instructor leads a class-wide discussion. Participants from all teams shared their thought process and POGIL-like group discussions. The instructor provided clarifications for lingering misconceptions and questions, and assisted participants with tweaking their combination of D/C/V questions for their chosen topic.

*Workshop Participant Roles within teams*

Our participant teams consisted of 4 distinct roles [25]: Manager, Recorder, Presenter and Reflector. The Manager kept the team focused on the task, managing time throughout the POGIL-like class session. The Recorder recorded answers for the team. The Presenter presented answers (or questions) to the class and the instructor at the end of the session. The Reflector considered how the team was working and how it could improve in the future. For each POGIL-Like session, we gave each team member a role card that indicates their role and its responsibilities. We offered additional timely guidance as participants worked in teams to create POGIL-Like content for the chosen section of the course they each selected [18, 27].

*Activity development during the workshop: Models, E-I-A cycles and D/C/V questions*

A model in a POGIL-like activity denotes the content that we would provide for students to know, during lectures or required readings [32], but presented with action verbs, figures, pictures and tables as needed, instead of copious quantities of plain flowing text. We used a combination of three types of questions -Directed (D), Convergent (C) and Divergent (V) questions. Directed questions are based on prior knowledge or provided information and are rarely difficult to answer. Convergent questions require more effort, but most students or teams will reach similar answers. Divergent questions also require more effort, but students and teams will often reach very different answers and explore broader issues [1]. Each of these D/C/V questions were intended to encourage the students towards either Exploration (E), Concept Invention (I) or Application (A) [26].

In each of our POGIL-like activities, we included one or more models. We followed each model with an activity. Each activity contained some combination of E-I or E-A or I-A questions, which also correlated to the D/C/V classification. For example, an I/C question would indicate that it was a concept invention question that was convergent, an E/D question be an exploration question that was directed, and an A/V question would be an application question that was divergent. In addition, we included explicit Content Learning Objectives (CLO) and Process Learning Objectives (PLO) in each activity. In our lab exercises, we designed each activity to focus on 3-4 technical concepts and 1-2 process skills, to be completed within 40 minutes. This also meant that our participants aimed to develop models and activities with CLOs and PLOs, with a variety of questions including D/C/V questions, incorporating E-I-A cycles, for the section of the course they intended to utilize POGIL-Like in.

## Results and Discussion

*Pre- and Post- survey quantitative results*

As we can see from Appendix C, all our pre and post survey questions were in the True/false format. We designated answers as correct based on whether the answer favored active learning or not. We analyzed the pre and post survey responses for difference in correctness, using a one way non-parametric ANOVA test. Our Chi-Square values for the Kruskal-Wallis test was 45.50 with DF=1. At an α level of 0.05, we determined the p value for statistical significance and found the difference in answer correctness between the pre and post survey results to be statistically significant ($p<0.001$). We present our results in Figure 1.

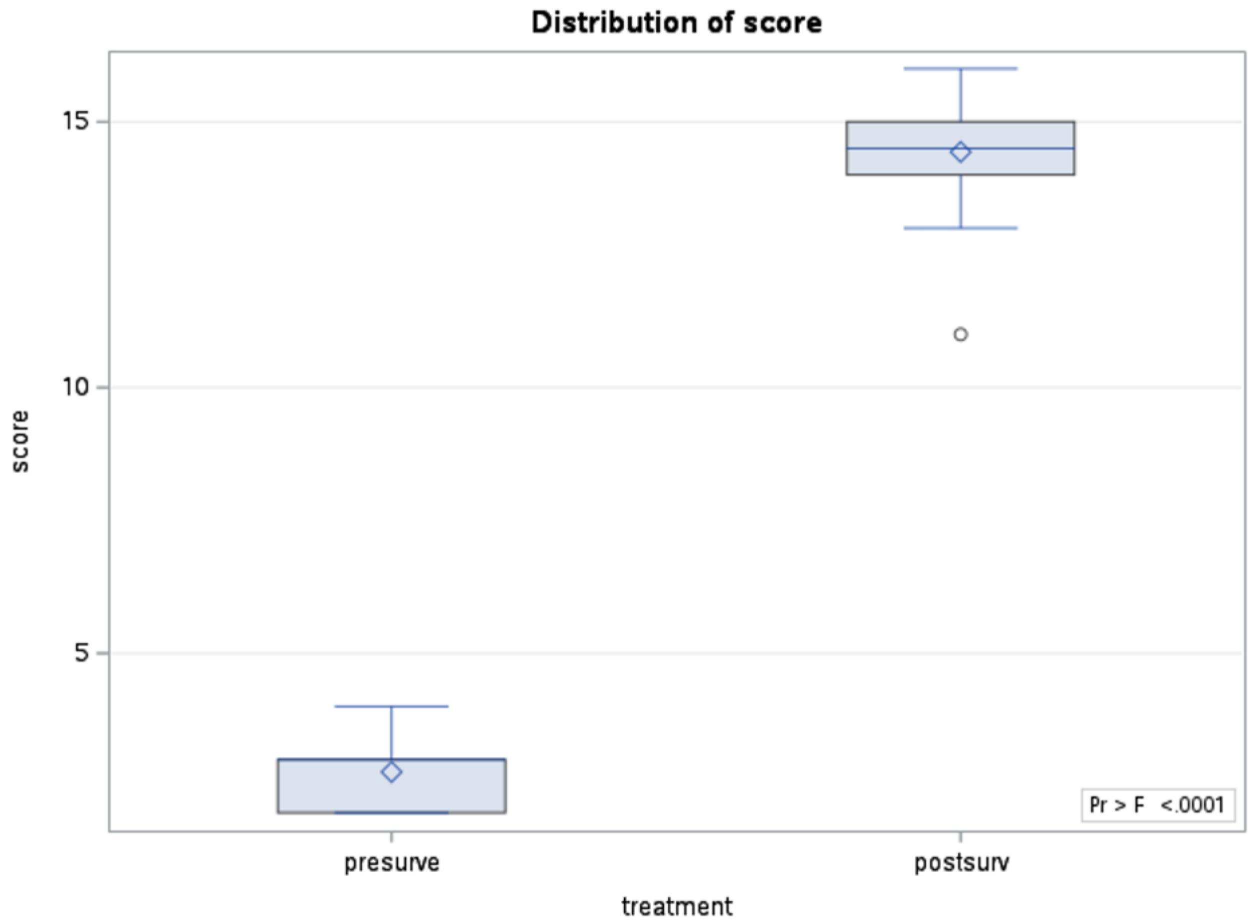


**Figure 1: Distribution of Pre vs Post Survey scores**

Our analysis of the pre survey responses indicated that a majority of the participants (80%) did not have familiarity with the dynamics of small group active learning pedagogies in the classroom. Their responses on the pre survey skewed heavily towards favoring traditional lecture styles where assignments, exams, and classroom lectures dominated the teaching and learning process. However, the post survey responses were completely skewed towards active learning concepts being perceived as not just valuable, but almost essential. 100% of our participants agreed on the role of the instructor as not just a knowledge transmitter, but as a facilitator of learning, where students can take ownership of their learning to at least a partial extent within the classroom through active learning approaches such as PI and POGIL-Like that they learned.

During the workshop, 100% of the participants met all the goals we had set out to accomplish. Every participant was able to identify specific topics for their courses to be taught using PI and POGIL-Like and developed classroom materials for the same. When we analyzed the pre-survey responses, we found that all the participants who responded indicated that they had no prior experience with active learning in the classroom, particularly, PI or POGIL-Like.

*Qualitative results from participant feedback*

We asked our participants about their impression of the workshop, what went well, and what could be improved for future iterations. All the participants who responded mentioned that they found the workshop to be very useful. PI and POGIL-Like being a learner-centric teaching methods, the participants found that they learned with ease and fun in a friendly environment with their peers. We discussed Active Learning in the Indian context, identifying elements of PI and POGIL-Like as active learning strategies for class room teaching specifically in the Indian context, and discussed strategies to make these pedagogies effective in the Indian context.

The feedback and reflection on these strategies yielded very positive impressions from all participants. Indian classrooms tend to have larger numbers of students in the classroom, and one of the potential concerns that participants voiced is the management of the small, structured teams that POGIL-Like demands. Our discussions with the participants mentioned that one way to address this potential issue would be to train the Teaching Assistants in helping facilitate POGIL-Like, since most classes that our participants taught tend to have TAs in the classroom. The second impediment that participants foresaw is a common impediment that transcends cultures- the lack of time to “cover” all the content. The heavy process elements involved with engaging students in active learning means that instructors have less time to “teach”, and this could potentially mean that less content is covered [45]. Our discussions also indicated that a work around for this would be to adapt these pedagogies to offload less consequential content, that might not require higher levels of thinking, typically knowledge-based content, to a flipped classroom approach. As for the workshop itself, all participants indicated that they were very satisfied with the format, content and pace of the workshop. However, 80% of participants felt that it might be beneficial for future iterations of the workshop if PI and POGIL-Like were offered as separate workshops, with extra days in each workshop. In this workshop we had facilitated and assisted participants in developing their own classroom materials for one topic each, for PI and POGIL-Like. Participants relished the opportunity to develop their own classroom materials for PI and POGIL-Like and indicated that if the pedagogies were offered as separate workshops, they would like to have the extra days dedicated to helping participants develop more classroom materials for the pedagogies.

We performed an analysis of the qualitative feedback and comments from the participants through the process of coding, chunking and theming. Two of the three organizers participated in this process. We established inter-rater reliability between the two coders, and distilled the following themes:

1) Participants saw the value of collaborative work in groups; they also saw that it is possible to generate meaningful discussions in a large class (which is common in the Indian context), and that students, with the right guidance and facilitation from the instructor, could learn from their peers.

2) Participants concurred with the idea that formal understanding of basic concepts needs to be supplemented with problem solving, as a nod to the Process and Content oriented aspects of POGIL-Like. We think that the aspects of PI and POGIL-Like that encourage students in the classroom to learn from their peers in a guided setting, also helped our faculty participants learn from each other and probe deeper into how students learn.
3) The difficulties that our faculty participants felt during the learning process, especially with lack of time, alerted them to what their students might face while learning through these pedagogical approaches as well.

## Future Work

The main difficulty that our participants foresaw and experienced, was a lack of time to convey everything they wished to in a class session, due to a) the process-heavy elements of the POGIL-Like pedagogical approach, and b) the repeated PI discussion time slots that take up time away from lecture. Some directions for proposed future work in this area include customizing the process-oriented elements for POGIL-Like to suit the Indian classroom, and develop strategies to strike the right balance between the content of the flipped classroom vs what is actually discussed during PI in class.

## Conclusion

We have presented, in this paper, the findings from a 4 day workshop that we conducted in India, to introduce engineering educators to PI and POGIL-Like.

We accomplished the goals we set out to achieve through this workshop.
1) We introduced PI and POGIL-Like to engineering and science educators in India, specifically to University faculty members from several universities in India, belonging to several engineering departments, teaching a wide variety of courses.
2) We helped participating faculty members identify sections of courses with specific topics they teach at their Universities that could be taught using PI and POGIL-Like.
3) We assisted them in developing classroom materials for both pedagogies in their respective disciplines, that they could take back with them and implement in their courses. To this end, we utilized in person classroom instruction along with handouts, hands on activities and lab exercises, and group work.
4) We identified potential impediments to implementation of PI and POGIL-Like in engineering classrooms in India. We obtained and analyzed data through pre- and post- workshop surveys to accomplish this goal.

Our workshop was introductory in nature. Most of the faculty members had not been exposed to active learning pedagogies prior to the workshop. All our participants engaged with the pedagogies wholeheartedly and gave valuable feedback on how to improve future iterations of the workshop.

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## Appendix

### A. Complete Workshop Session Details and Agenda

| Time | Sessions | Outcome |
|---|---|---|
| 08.30 am – 09.30 am | Registration and Inauguration | |
| 09.30 am - 11.00 am | Active Learning – Discussion, Pre- Workshop Survey | Discuss current trends in active learning in engineering education and potential benefits and challenges; complete pre-workshop survey |
| 11.00 am - 11.30 am | Tea/Coffee | |
| 11.30 am - 01.00 pm | Peer Instruction (PI) – a primer | Identify a section of a specific course you teach where you could implement PI. Identify components of PI in combination with a flipped classroom approach for that section. |
| 01.00 pm – 02.30 pm | Lunch | |
| 02.30 pm - 04.00 pm | Learning Outcomes for PI | Create learning outcomes for a section of your course where you wish to implement PI |
| 04.00 pm - 04:30 pm | Tea/Coffee | |
| 04.30 pm - 05.30 pm | Implementing PI – Clickers and Student Response Systems (SRS) | Create account on an SRS, create a module, add students and TAs |
| Day – 2 | | |
| Time | Sessions | Outcome |
| 09.30 am – 11.00 am | Implementing PI – question creation | Design and upload PI questions for the section of course you wish to implement PI |
| 11.00 am – 11.30 am | Tea/Coffee | |
| 11.30 am - 01.00 pm | Implementing PI - demonstration | Work in small teams; participate in live demonstration of PI in a classroom |

| | | |
|---|---|---|
| 01.00 pm - 02.30 pm | Lunch | |
| 02.30 pm - 04.00 pm | Assessment | Create assessment plans for PI implementation |
| 04.00 pm - 04.30 pm | Tea/Coffee | |

Day – 3

| Time | Sessions | Outcome |
|---|---|---|
| 09.30 am – 11.00 am | POGIL-Like – a primer | Identify a section of a specific course you teach where you could implement POGIL-Like. Identify components of POGIL-Like you wish to use for that section. |
| 11.00 am - 11.30 am | Tea/Coffee | |
| 11.30 am - 01.00 pm | Learning Outcomes for POGIL-Like | Create learning outcomes for a section of your course where you wish to implement POGIL-Like |
| 01.00 pm - 02.30 pm | Lunch | |
| 02.30 m - 04.00 pm | Implementation – roles and questions,<br>activity writing | Develop one D, C, V question each. Develop one E-I-A cycle with these questions. Wrap it inside a POGIL-Like activity and document the activity. |
| 04.00 pm - 04:30 pm | Tea/Coffee | |
| 04.30 pm - 05.30 pm | Implementation -Assessment | Create assignment on Moodle or other LMS for the POGIL-Like activity session (with a single E-I-A cycle and corresponding D-C-V questions) |

Day – 4

| Time | Sessions | Outcome |
|---|---|---|
| 09.30 am – 11.00 am | POGIL-like demonstration | Participate in the POGIL-Like classroom |
| 11.00 am – 11.30 am | Tea | |

| | | |
|---|---|---|
| 11.30 am - 01.00 pm | Instructor challenges; Post Workshop Survey; AMA | Discuss challenges with adopting PI, POGIL-Like, and active learning in general. Complete Post Workshop Survey. |
| 01.00 pm - 02.30 pm | Lunch | |
| 02.30pm - 04.00 pm | Award Ceremony | Distribution of certificates; Vote of Thanks |
| 04.00 pm - 04:30 pm | Tea and End of Workshop | |

**B. Sample handout**

HANDOUT - DAY 1
Name:
Institution:
Department and Rank:

Session 1: Introduction to Active Learning

Discussion 1:
For each classroom respond to the following questions and post in the discussion below:
1) What aspects of this classroom would support cooperative learning?
2) What aspects would make cooperative learning challenging?
3) How might you structure a cooperative learning activity in this space?

Discussion 2:
What are your concerns about using active learning activities & techniques?

Discussion 1: What is a learning objective and an Informal Group Cooperative Learning assignment (to support that objective) that you could use in your own discipline? Don't forget about Bloom's taxonomy. Post in the discussion below.

Session 2: Peer Instruction- a Primer

Outcome 1:

Identify a section of a specific course you teach where you could implement PI. Decide on how many class sessions you wish to implement PI in, and how long each class session is. Also indicate the topic that will be taught in each class session.

Outcome 2:

Identify components of PI in combination with a flipped classroom approach for that section.

What aspects of the sessions can you flip the classroom in? And what do you think might work best to flip the classroom with?

Session 3: Implementing PI – clickers and SRSs
Go to https://polleverywhere.com
Create a free instructor account
Create a course
Create a module on the course
Add dummy students and TAs

## C. Pre- and Post Survey questions:

The pre and post surveys contained the following True/False questions:

1. The main result of noise in a large class (more than 40 students) is that it disturbs the process of learning.
2. The instructor, besides his/her role as knowledge provider, is to guide students in the learning process.
3. The students can, during peer discussions, discover new scientific knowledge.
4. The instructor, in addition to his/her duty as a teacher, should become familiar with students' learning difficulties.
5. Learning in large classes reduces learning efficiency.
6. It is legitimate to test students on subjects they learned on their own and that were not studied in class.
7. The students' limited scientific knowledge does not allow them to build new knowledge.
8. It is important to define in the syllabus components which are very important and will not be waived, and components which can be waived.
9. Collaborative work in groups allows efficient learning in a large class (more than 40 students).
10. There is no chance to generate discussion in a large class that includes most of course students (more than 40 students).
11. It is important to require that students should submit all of their assignments in basic courses.
12. The instructor should focus on his/her role as knowledge transmitter.
13. Background noise in a large class (more than 40 students) may be an indication of groups of students learning efficiently.
14. Instructors' feedback related to preparation of assignments or summaries encourage students to learn.
15. The instructor should present to the students all of the course materials during the lesson and not rely on students learning on their own.
16. It is preferable to focus mainly on problem solving and less on formal understanding of basic concepts.
17. Discussions between students related to course materials are vital for a deeper understanding of the course material.
18. The instructor should make every effort to identify and address students' learning difficulties.

19. In large classes, during work group, the instructor has the opportunity to provide personal guidance.
20. The final exam is not a good enough tool for providing a student feedback about his knowledge and skills in the course.
21. Students will not learn beyond what they must even in a course that generates interest and curiosity.
22. During the examination, don't ask students questions on subjects that were not studied in class.
23. The instructor may present part of the study program in class and another part leave for guided learning.
24. The instructor doesn't need to know the students' difficulties in his/her course.
25. There is no way for personal guidance in a large class (more than 40 students).
26. Students can be evaluated in basic courses only by means of a final exam.
27. It is possible to create a course atmosphere where students read their task assignments before the lesson.
28. Students learn each time a limited part of course syllabus, therefore it cannot be expected from them to generalize and create new scientific knowledge.
29. It is important to cover the entire syllabus during the course.
30. It is preferable to emphasize the technical aspects in problem solving over the theoretical aspects.