# iGEM TEAM MEETINGS: SETTINGS FOR CONVERSATIONS ON TEACHING AND LEARNING

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*Every November, the University of Calgary iGEM (international Genetically Engineered Machines) team presents their synthetic biology project to the world. Weekly team meetings are a microcosm of the iGEM experience of bringing ideas to fruition. The peer teaching, mentoring, and consultations that occur at these meetings are triggers for deeper conversations on teaching and learning. In the workshop described here, participants were invited to experience a simulated iGEM team meeting environment, where instead of synthetic biology, issues of teaching and learning were the subject of their conversations.*

We presented a workshop at the 2017 University of Calgary Conference on Postsecondary Learning and Teaching to show how team meetings provide a setting for conversations on teaching and learning. In this paper, we will expand on the material presented at that workshop (Arcellana-Panlilio & Lohmeier-Vogel, 2017), describe how the workshop itself unfolded, referring to contemporaneous field notes, and conclude with some reflective comments.

## BACKGROUND TO THE iGEM EXPERIENCE & COLLABORATIVE RESEARCH

The iGEM competition assembles student teams from colleges and universities around the world, to present projects that propose synthetic biology solutions to real problems (iGEM Foundation, 2017). Recruitment for iGEM team members begins with information evenings to gauge interest, then applications are received and assessed, and interviews are conducted. The team selected will have students in the first, second, third, fourth, or even fifth year of their program. They will come from faculties across campus: usually science, medicine, and engineering; and on the rare occasion, arts and business. Their lab or research experience will vary, as will their fields of interest and of prior knowledge. The goal is to put together a multi-disciplinary team of undergraduate students who will bring the diversity of their training and experience to bear on the problem they will address.

Being on the iGEM team at the University of Calgary offers a unique research experience, because its direction is student-driven, rather than determined by a principal investigator's research priorities. iGEM teams are never assigned a topic; they define and develop their own team project. It should be stressed, however, that students do not work in isolation, but with other team members, student mentors, and faculty advisors in a collaborative research environment.

In her review of "Knowledge and power in collaborative research: A reflexive approach" by Philips and co-authors, Memon (2016) identifies the central message of the book as being that "dialogue in its various… forms is critical for new knowledge that must be co-produced collaboratively." (p.474). Communication, in the sense of its being a back-and-forth exchange of

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ideas and perspectives, is essential to collaborative research. The iGEM team meetings provide the time and place for those necessary conversations.

The first meetings, with both students and mentors in attendance, begin in the winter term (from January to April), where several research topics are proposed. Each team member then chooses one of these topics to delve into more deeply, reading the literature and gathering information with regard to the aptness of synthetic biology as an approach to this topic, the resources available for investigating the subject, and the potential outcomes and applications for society.

During this time of individual research, weekly team meetings are occasions to test their ideas, receive feedback, and to identify strengths and weaknesses of their proposals. Peer mentoring from students with more research experience, or a different degree major, yields benefits to learning such as providing "new perspectives and expansion of ideas, positive and encouraging reinforcement, supportive connection … [with other] students, and probing questions to think more deeply." (Vaughan, Clampitt, & Park, 2016, p.1). Students also converse with former iGEM students or faculty advisors to avail themselves of these mentors' broader experience and deeper understanding of issues. These multi-layered conversations allow students to wrestle with their ideas in social interactions before internalizing them and making the ideas their own, reminiscent of Shulman's model (1999) for the enhancement of learning. Eventually, students prepare an executive summary of their proposed project.

At the team retreat (which is code for a longer meeting, thankfully with food to sustain), each project idea is discussed, with a team member acting as champion to field questions and provide clarification on fine details of approach or methodology. Then the proposals are put to a vote and one team project topic is chosen from the individual proposals. After the vote, the entire team gets behind that one topic and everyone collaborates on developing it into the team project. Sub-groups form according to project needs, member interest, and academic program, with the composition of some groups more fluid than others.

Team meetings continue throughout the spring and summer months, when the real research happens. These meetings are a means of informing of progress in the sub-groups, questioning and interpreting of experimental data, and planning for the next week's activities. The fall term is spent preparing for the competition in November, completing the custom website (wiki), which documents the work done on the project, making the poster, and putting together the slides and demonstrations for the oral presentation. Here, the team meetings remain highly collaborative, as the group critiques multiple versions of wiki pages, poster drafts, and oral presentations.

## iGEM CONVERSATIONS VIS-A-VIS TEACHING AND LEARNING

The multi-layered conversations at these weekly iGEM meetings contextualize conversations on teaching and learning. Whether face-to-face or virtual encounters on the web, through platforms such as Google Docs or Facebook, these conversations among students, mentors, and advisors provide opportunities for teaching and learning that permit the iterative development of thoughts and plans of action for future research.

The immediate impact of a learning culture nurtured by multi-layered conversations is the achievement of project objectives. In the case of the iGEM program, that achievement is manifested by the awards and recognition won at the competition, but more tellingly, by what the students go on to achieve after iGEM. These accomplishments demonstrate some of the other, unspoken benefits of iGEM team meetings, such as providing practice and feedback on nascent

skills for asking questions and identifying critical issues, for seeking answers, and contributing to the larger conversation of research and scholarship.

To the faculty mentors, these multi-layered conversations trigger deeper, reflective conversations on teaching and learning. At team meetings, we have returned time and again to the question of mastery and how it shows. We have observed students demonstrate mastery by teaching one another concepts: of synthetic biology, to be comprehensible to a non-biology major; or of thermodynamics, to be understood by a non-engineer. These students demonstrate a level of mastery marked by a consciousness of competence on a subject, and the ability to integrate their knowledge through practice (Ambrose, Bridges, & Dipietro, 2010), in this case, by teaching their peers. We have seen students develop mastery of the subject matter of their project, as they design and perform experiments, interpret their results, and coherently communicate their findings to the world.

## APPLICATION OF THE TEAM MEETING MODEL IN A WORKSHOP SETTING

The workshop we presented at the 2017 Conference on Postsecondary Learning & Teaching highlighted the meaningful, multi-layered conversations at play in iGEM team meetings. We focused on how these conversations mediate the process of deciding on a team project. Then, simulating the iGEM team meeting environment, we invited the participants to engage in a similar process to identify a real world teaching & learning issue that can be addressed by research and scholarship.

The workshop had the following learning outcomes, such that by the end of the workshop, the participants will have been able to:

1. Experience a meeting environment where conversations among individuals with different backgrounds allow groups to brainstorm and consider issues of teaching and learning to investigate;
2. Present these research ideas to one another, for examination, discussion, and evaluation, in order to decide on one topic that all participants would pursue; and
3. Reflect on the workshop experience with respect to promoting a culture of teaching and learning.

The workshop participants self-organized into three groups: the first was a pair of colleagues at similar stages in their career, both from Chemistry; the second was a Continuing Education specialist and an undergrad student in Kinesiology; and the third was a new instructor from Mechanical Engineering and a more seasoned instructor from Biological Sciences.

We had planned the session timings to handle up to five groups of participants, and so had allotted only 5 minutes to brainstorming a teaching and learning issue and discussing the idea to answer the following questions: (1) Why is the topic worthy of investigation? (2) What are the pros and cons of researching this topic? and (3) What approach might be taken to research this topic? Since we had fewer groups than expected, we allowed the participants twice the amount of time for this portion of the workshop. Even with this small number of groups, the conversations that arose among the participants were as varied and multi-faceted as would have been expected from the diversity of disciplines and career stages represented. The field notes for the observations below were taken during the discussions that followed the initial brainstorming session.

The first group decided to explore the incorporation of puzzles in the classroom. Given that our workshop was scheduled for the afternoon of the last day of the conference, we anticipated that by that time, participants would have been exposed to quite a few teaching and

learning topics. Thus, it was not entirely unexpected that when called upon to think about an issue worthy of investigation, participants should suggest a topic that had been covered in another session (Kawash & Reid, 2017) at the conference. The participants in this group were colleagues from the same department and it was evident from their interaction that they knew each other well. Their main discussion point was determining how these puzzles could be linked to course outcomes, and they already had ideas about how they would go about investigating this.

The second group asked the question: What role can students play in shaping the path that a course takes in large classes? To address this, the group considered having lectures evolve based on an idea of reciprocity and open communication. They suggested the use of a platform, such as Microsoft Forums, to ask students a few questions to make a rapid formative assessment of student learning. To gauge the effectiveness of a strategy, the group noted the need for some baseline data, such as on drop-out rates for students in large classes, prior to beginning the study. During the ensuing discussion among all the participants, investigating the value of peer-teaching and Just-in-Time teaching (Novak, 2011) were suggested as possible approaches.

The third group asked how student success in their future careers can be related to the grades they receive as undergraduates. The group recognized that a long-term study of this question would be required. Alumni records could provide useful information. However, ethics would certainly have to be considered.

In the iGEM model, a decision would have been made as to which topic would be pursued by the whole group. Based on the richness of the discussions following each group's presentation, the second group's topic on the role students can play in shaping courses in large classes would likely have been chosen. From there, all the members would work together on the chosen topic and form sub-groups based on interests, skill sets, and fields of expertise.

To end the workshop, we distributed neon colored cards decorated with stick-on gems, and we asked the participants to think about the workshop and to ask: Did I discover any gems that I might take away and apply to my own practice? We did not collect these cards, although in retrospect, it would have been illuminating to read what gems participants had discovered. One participant did share that he could have an iGEM-like meeting set up with his students "to see how I can better help them in the course."

It is noteworthy that the workshop successfully modeled the inter-disciplinary nature of the iGEM team environment. The types of conversations that took place depended very much on the participants involved and their own interests and areas of expertise. Having participants with disparate backgrounds made for richer conversations, especially while brainstorming and evaluating ideas. On the other hand, having overlapping spheres of experience and expertise helped participants to make concrete, immediately applicable suggestions.

Having a student among the participants offered a valuable perspective, while having faculty participants who have taught large, foundational level courses, conversing with those accustomed to smaller, more specialized courses, afforded a spectrum of experience from which conversations sprung.

## CONCLUDING THOUGHTS

In this paper, we present the iGEM team meeting as a setting for meaningful, multi-layered conversations that mediate the process of developing, executing, and presenting a synthetic biology project that addresses a real world problem. The opportunities for teaching and learning that accompany this process positively influence team success. However, the larger,

more lasting, impact of a learning culture nurtured by the multi-layered conversation is in catalyzing conversations that deepen the understanding of learning itself, glimpses of which we have already seen as we observed the iGEM team in action, and as we conducted the workshop and invited participants to consider issues of teaching and learning.

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