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Impact of Facilitation in the Learning Process in STEM

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Abstract

The role of facilitator, and facilitation strategies, are components that sometimes get overlooked as important in promoting collaborative interactions, such as with group work. Being able to work effectively in a group is a required skill for most disciplines, in particular for those in the Science, Technology, Engineering and Mathematics (STEM) fields. It is also central throughout the Professional Development Program (PDP) developed and run by the Institute of Scientist and Engineer Educators (ISEE), starting with group formation and leading all the way up to the final culminating activity. As such, PDP teams are taught facilitation strategies. Keeping in mind a group's goals and what their measures for accountability are, the facilitator should be able to give constructive feedback and actively assess the team's progress on the go. In this process, the facilitator can identify early on issues that can then be addressed before they become pathological. In this paper, we discuss from our experience as PDP participants and facilitators, what are different spaces we have applied facilitation strategies, what are some of the strategies that have worked throughout the years to improve group work, and what observations from the group help us make the best possible assessment.

Keywords: active learning, course design, equity & inclusion, facilitation, recognition, STEM identity

1. Introduction

One of the main components in the Institute for Scientist & Engineer Educators (ISEE) Professional Development Program (PDP) is creating authentic and inclusive Science, Technology, Engineering, and Mathematics (STEM) learning experience. This is done in an inquiry framework that uses six key elements: Cognitive STEM practices; Foundation STEM content; Intertwined content and practices; Mirroring authentic research and design; Ownership of learning; Explaining using evidence. All six elements are fundamental for the inquiry process to happen and they all appear throughout the learning process in multiple places (for an in-depth overview, see Metevier, et al.'s (2022) description of the Inquiry Framework). In this article we will focus on the importance of the facilitation during an inquiry activity and its implications.

Facilitation is defined as the small moment-to-moment interactions that occur as an instructor or mentor is guiding a learner engaged in STEM (Ball et al., 2022). For example, a response to a student's question during class, or an instructor's decision to let a group of students figure out how to make sense of experimental equipment rather than explain it to them. The practice of facilitating learners can be viewed through the mediational effects of discourse, material tools, roles and power dynamics, and the norms of the community, and how all these factors are intersecting, relevant to the activity at hand (Ball et al., 2022).

Some of the main facilitation moves we will explore are those involving group dynamics, in particular how group formation can affect the activity and how the facilitator may ease or promote positive group interactions. We will also explore how facilitation is a key component to incorporate diversity, equity and inclusion in the learning process. In general, we also agree that facilitators should try to engage students with open questions to give them ownership of their learning process without giving away too many answers.

In this article we will explore three different scenarios and we will walk through the facilitation moves that were applied or practiced. In particular, we have observed that the practice of equitable facilitation moves has a major impact on promoting a more equitable and inclusive classroom (Seagroves et al., 2022). As an example, we have identified that the attitude of the facilitator with their facilitation moves may create a more realistic STEM environment, helping to generate a sense of belonging to the scientific community and having ownership on their own work.

2. Facilitating flipped classrooms, the studio physics model

2.1 Introduction: The studio physics model

The concept of Studio Physics originated from the Rensselaer's Physics Education Group in 1994 (Wilson, 1994). Its main characteristics are the integration of a lecture-laboratory format with minimal lecturing time and lots of collaborative student work, along with a higher level of faculty-student interaction than in the traditional model. This model presents several advantages with respect to traditional lecture settings.

In the studio model, students learn concepts and immediately apply them in a real setting, while also having much more contact with the instructional team. This is composed by a faculty member and several graduate teaching assistants and undergraduate learning assistants, with a ratio of 1 instructor per 10–15 students. Another major advantage is that students get to use real equipment as well as computers and simulation software while they learn, learning transferable skills along the way. In this way diversity, equity and inclusion issues are addressed in a natural way. This also gives students ownership of their learning and a sense of belonging to a bigger community of scientists (Ball et al., 2022).

This new teaching model changes completely the way that the instructional team interacts with students, and specifically allows for a lot of facilitation during the learning process. Many studies indicate that all students learn better in active engagement courses (Cummings et al., 1999; Hake et al., 1998, McDaniel, et al., 2017). In this section we will discuss different facilitation moves that improve the quality of the class. Some of these moves can be done before the class even starts and some of them are applied real time.

2.2 Facilitation moves:

2.2.1 Before class starts

A major component of the studio class is **group work**. Students have to work together solving problems and working with experimental equipment. Diverse and equilibrated teams make the work much smoother. In our experience groups of three students are optimal, as groups of two it seems to fall short with regards to coordinating and organizing tasks. Groups of four, on the other hand, start being too crowded to manage properly and often one of the students lacks any specific tasks to do and loses interest. In order to make it more manageable with the amount of instructors available, we organize the students in groups of three and accommodate two groups in the same big table, then those two groups form part of a bigger six people master group. Each of them has to submit their own work but they are encouraged to work together.

When it comes to setting the members in each group. We have observed that having a survey, where we can learn about the students, prior to the first activity helps a lot in organizing the groups. Several types of questions can be asked depending on how the students want to be divided. In our experience, general demographics like gender, race, language, and year of studies, do help when making groups. We have experienced that groups where minorities are isolated do not work as effectively as when those minorities are paired up in the same groups for example. Academic performance questions can also help in the process: how many previous math or physics classes were taken, any flipped classes, average GPA, etc. In our experience, mixed groups with experienced and less experienced students work better than separating the groups by their average GPA. University of Purdue developed a tool called catme that integrates a powerful survey that allows for the automatic creation of groups using a previous survey. Starting with equilibrated and diverse groups, will ease the amount of correction that will be needed later on during the course of the class.

Once the semester is running, it is also important to assess other aspects of group work that may not have been as obvious in the previous survey and if needed groups can be shuffled. In our experience it is good to have a natural point in the semester in which groups are to be changed, and make that an expectation to the students, that way they do not feel like they have failed in their previous groups. If there are some major issues, groups might also be reshuffled at any time.

Another important aspect to account for in the survey is the students' **level of previous knowledge** about the subject topic itself and also the teaching model. Students that have been exposed to a flipped classroom beforehand can start working directly in the studio model with very minor resistance. Students that are only used to a traditional lecturing model, on the other hand, may need to have some activities built in at the beginning of the semester to transition from the traditional model into the new one.

In general, if students expect their instructors to give them answers, they may feel anxious if they do not get them right away. Thus it is very important in that case to set the culture of the classroom from the beginning. For example, clarifying what the instructor's role is and not making exceptions. For instance, if students did not read the information they were supposed to, and the instructor gives a 20 min introductory lecture, they may start to expect that to happen every day. The studio model strives for the students to navigate through inquiry to find their own conclusions. This can be stressful thus it is very important to set clear expectations from the beginning. The prior knowledge can be gathered from extra credit quizzes before class and can be used to build in scaffolding activities to strengthen concepts that were assumed to be known but sometimes are not.

2.2.1 During class

By design, the studio model allows for a lot of interaction between instructors and students. One of the best tools that we have used in many of these interactions is the use of **open questions** when prompting the students. Often in a classroom setting we tend to use more closed questions that do not give room for the students to navigate their own thought process, either they know the answer or they don't, but the instructor does not really learn anything about the thinking process that is going on in the student's mind. A closed question is simply one that the participant can answer 'yes' or 'no' to. An open question requires far more detail and it invites the person responding to provide information into how they feel and what they think about a subject. These questions can cause frustration to the students at the beginning because they are expecting close answers to their questions. Students may even think that the instructor does not know enough or is not well prepared. It is very important to set expectations from the beginning and be very upfront about the open question method that is being used.

With this model we have also learned that **peer interventions** are sometimes more effective than those coming directly from a faculty member. Students feel more comfortable showing their vulnerability to other undergraduate students than to their instructors. Because of that we have incorporated the use of Undergraduate Learning Assistant (ULA) in the classroom. It is very important to spend a good amount of time training those ULAs in the pedagogical model, so that they themselves also base their interactions in the usage of open questions. ULAs that previously took the class in the studio format have proved to be the most effective when teaching it themselves (Mazur, 2014; Pawlak et al., 2020).

During the class there are mainly 2 types of activities: experimental laboratories and solution of conceptual and quantitative problems. Using open questioning is always a good strategy for both situations but we can also specify some other moves that help in the learning process.

2.2.1.1 For conceptual and quantitative problem solving

In our model students are supposed to read materials and watch videos to learn the concepts before class. Once in person, we use a flipped model. We provide conceptual and mathematical problems, starting from simple to more complex, and students solve them in their groups. Each instructor is in charge of facilitating the work of two to three tables with two groups of three students each. Early in the semester students tend not to read the materials before class which makes it very challenging for them to be able to solve the problems. At this time, it would be easy for the facilitator to do a short summary of the topic so the students can work on the problem but this sets a dangerous precedent. Instead, we propose to build in some extra time during the first sessions of class to prompt the students to **find the information on their own** while telling them in the future they will not have that opportunity and they should prepare before class. In the middle of the semester it should not be a problem anymore.

Once the students are working on their problems within their groups, facilitators should **observe** and **prompt open questions** every so often to **assess** if they need **intervention**. Each activity is timed in a way that the facilitators build in some time for the groups to explore options and after that time, if they are still very lost, the facilitator may need to discuss with them. Facilitator should always try to prompt open questions to help the group get in the right direction. It is important to set the tone from the very beginning, that the instructors do not give direct answers or tell the groups if an answer is right or wrong. Very often there is more than one way to solve the problem. When a group seems stuck, it is often productive to encourage them to **discuss with the other group** in their same table or even in adjacent tables.

Each group is given a big white board to write their results, this way the facilitator can always have a glance of the progress.

2.2.1.2 For experimental labs

In this case students are given an experimental problem and are provided some equipment. In general, they also get some general instructions of how the equipment works and a clear goal to research during the activity. These activities are not guided so different groups may be running completely different experiments. The philosophy is very similar to the one used for conceptual problems. We build in some time to discover the activity and let the groups **explore**. If they seem to be lost after that time we do our first facilitation move to try and guide them. Before that, we prompt them to **talk to other groups** and see what they are doing to get ideas. After about half of the time, we look at the white boards and if they are still very far, we start giving closer guidance: If they have not started measuring we can ask questions like: what are the possible magnitudes you could measure? What are the variables involved? If you want to learn something about A, what are the things you would need to measure? If they seem stuck in the analysis part, we can refer them to the readings, typical constriction points can be solved by showing them how the different variables relate, how to plot data or how to make a data fit. Understanding uncertainty is another typical concept that may need some help. For that we have created several readings that talk about statistical analysis of uncertainties.

2.2.1.3 After the activity, summarizing learning

After each activity, there must be a whole classroom summary to wrap up the concepts learned in that day. Each group presents their findings in front of the classroom, they can use the white boards that they worked with during the activity and have a given group present their findings in front of the classroom. The role of the facilitator in that part is to provide a **safety net** for the group so they do not feel anxious in case they do not know something. The facilitator acts as a host, organizing the questions and answers from the rest of the groups, and also supports the presenting group if they need assistance answering some of the questions. At the end of a whole class period, the facilitator puts together all the main learning goals of the day into a presentation and summarizes the taking points of the day.

2.3 Conclusion

In summary, the studio physics model is an innovative approach that allows for students to learn physics in an inquiry-based manner, with Diversity, Equity, and Inclusion (DEI) built into the model by design. The role of the facilitator in the model is fundamental. The success is dependent on a low ratio of instructor/student (1 to 10–15) and the interactions are structured and planned. The facilitator practices the Socratic method of interacting with students, using mostly open questions to give space to the students' own learning without giving away answers from the get go.

3. Mainland summer internship engineering activity

Engineering based activities, much like scientific activities, benefit greatly from inquiry based learning and it is very amiable to incorporate engineering principles (Morzinski, 2010). In 2005, we ran an Adaptive Optics engineering-based activity where we incorporated the principles of the inquiry process; using engineering practices to design an Adaptive Optics (AO) system. The participants were early career college students participating in the Center for Adaptive Optics summer internship program.

3.1 Engineering activity overview

The activity began with a set of AO demos where the participants could play with materials and generate questions. During this time, we also introduced the setup that could be used to test their AO system. Then questions were sorted into engineering challenges that the participants could engage on, slightly different from the usual scientific based inquiry activity. Instead, the challenge was to build something that could be used to correct an aberrated image. The process continued by allowing participants to form into small groups. At which point some time was allowed for the groups to play around with a set of materials that could be used to build their AO system. During the time the participants began brainstorming about the design, including useful ways to measure the aberration. The activity had a design phase and a test phase where the participants were encouraged to use the test setup to test their designs. During the test process the instructor could actively engage the participants and other groups to improve on their designs. The activity concluded with a quick demo of the final design and final recap.

3.2 Role of the facilitator during the activity

During the activity the instructors incorporated different strategies that facilitate the learning process. Though the main goal of the activity was to engage the participants in the engineering process, AO itself was a secondary goal. Previous to the challenge the participants had been introduced to AO in a lecture as a prelude to their internships.

3.2.1 Pre-activity instructor material preparation

Before the activity began, one of the exploration strategies that was used was to determine which set of materials could be used to achieve the goal. The materials were selected to give participants some flexibility of choice during the design phase but not so much that it would lead them on a tangent. Note that instructors did not select one perfect material that could accomplish the job 100 percent, but instead the selection was done so that during the test phase participants could determine potential tradeoffs on their designs. This created a situation where instructors could provide gentle nudges, by moving a piece of equipment for example, to allow for exploration, while still keeping students on task.

3.2.2 Initial exploration and question generation

The activity began with a set of AO demos where the participants could play with materials and write down questions and observations. The questions generation phase early in the activity, much like in scientific inquiry activities, was done to allow for a sense of ownership to develop. While the challenge was to build an AO system, participants were still encouraged to expand upon different areas, aberrations measurements, optical materials quality, phase correction, etc. Since the groups were formed with slightly different interests it allowed for an inclusive environment where participants could engage on something they were interested in.

3.2.3 Group formation

The questions and observations generated by the participants were grouped into similar ideas. We then asked the participants to select an idea to explore. This strategy allowed for a fluid group formation since participants were pursuing similar interests. For participants who were on the fence, instructors encouraged them to talk with other participants, sometimes pointing out other participants with similar interests. This strategy requires the instructors to pay close attention to the questions and also listen in to the conversations in the room, this is made simpler with multiple instructors as different areas can be delegated.

3.2.4 Engineering research phase

During the research phase, where participants were allowed to interact with the materials available, some decided to continue researching the actual problem by interacting with the test setup and demo stations. Here the instructors play a crucial role to prevent participants from deviating too far from the problem. Various strategies can be used here always keeping in mind not to give the participants the answers but be mindful to keep them on points. Though the interaction is largely dependent on the instructor and participant, the goal should always be kept in mind. One of the strategies that stood out, which is also prevalent in scientific inquiries, was for the instructor to step in and interact with the group. Sometimes this is discrete by playing around with the materials or moving a piece of equipment. As an example, in the AO activity case one of the instructors casually pointed a lamp at the reflective materials available and observed the reflected light on the wall. This immediately attracted the participants' attention and they began exploring it.

3.2.5 Engineering design phase

For the design phase the participants were provided with a drawing pad and markers so they could roughly sketch their design. The design phase was a mixture of exploration and design, brainstorm and redesigning, this largely mirrored the authentic research and design engineers work through. This was roughly half way through the activity and by this time the team dynamics were more or less observed. One useful strategy here is to engage all the participants, either one at a time or in group, and ask questions about the design. This is fine but care must be taken as different learners engage differently. Some are better at conversing with the group, others prefer to think for themselves and occasionally make contributions.

3.2.6 Engineering test and redesign phase

The test phase was more or less continuous, though instructors encouraged participants to test their design as the end of the activity approached. To simulate authentic engineering principles instructors can begin asking more questions about tradeoffs and limitations on their design. One useful strategy here is to encourage teams working with similar goals to observe each other, this allows for participants to spark new ideas and tweaks to their designs.

3.2.7 Participants presentation

In preparation for the final presentations participants were asked to think about their design and how to demo on the test bench. They were also instructed to think about the tradeoff they had to make and the limitations their design had, as well as improvements they could make given more time. For the final presentation the participants were allotted some amount of time to demo their "final" product on the test bench. It is a good strategy to collect examples of the goal through the engineering process for the instructor activity recap, it is always a useful strategy to point out to the groups about the current process they are engaging in.

3.2.8 Instructor led activity recap

For the instructor activity recap, it is always a good strategy to draw upon examples from the activity itself. In the case of the AO activity participants engage in the full engineering cycle:

- Ask Questions
- Explore and research
- Brainstorm and design
- Implement and modified
- Test
- Consolidate tradeoffs and limitations
- Back to asking

Pointing out to the students about the activity they engaged in and how this resembles engineering helps them visualize themselves as engineers.

3.3 Conclusion

While the AO system was the actual deliverable for the activity the main goal was for engineering practices. Thus the strategies were based around giving participants a glimpse of what engineering is about. This allowed for the participants to engage in an authentic engineering experience where they could work together in groups in an inclusive manner.

4. Leading a facilitation workshop for instructors of a one-week summer school

The Professional Development Program (PDP) developed and run by the Institute of Scientist and Engineer Educators (ISEE) introduced participants to strategies of facilitation through a series of readings and discussions that were a part of a larger leadership and teaching experience. For participants of the PDP, these strategies were designed to be incorporated in future teaching and learning environments as part of their leadership and professional development. Inspired by PDP curriculum and resources, a short (< 2 hr) workshop on facilitation was developed for instructors of a one-week intensive experiential learning astronomical instrumentation summer school. There were three overarching goals; 1. To introduce the summer school's equity and inclusion-minded goals and values (i.e., supporting an inclusive space within astronomical instrumentation), 2. Provide a primer on facilitation to promote a positive student learning experience, thus serving as a baseline for instructors of different background teaching styles and experience levels, 3. To create a collaborative space for instructors to connect and build community among instructional staff prior to the start of the program. PDP facilitation materials were used and modified so it was not necessary for learners (in this case instructors) to be PDP alumni to benefit. More specifically, participants may or may not have been familiar with facilitation as a strategy that can be designed deliberately ("active strategy") to support learning goals. The < 2-hour in person instructor workshop of mixed audience (post-doc, faculty, researchers, gender), some familiar with PDP curriculum and others not, were asked to think about facilitation as a deliberate strategy to shape student interaction to promote ownership and an inclusive group dynamic in lab style group work. The workshop was run by two PDP alumni, one of which was a PDP core instructor that assisted in development of the PDP curriculum. The following are insights (mine) as a PDP alumni on discussing facilitation strategies without scaffolding of the PDP structure and curriculum. I will briefly focus on two points of emphasis to consider, facilitation as an active strategy and an individual's lens that shapes facilitator's self-awareness to identify strategies.

4.1 Structure of the workshop

4.1.1 Prior to the workshop

Participants were asked to review a short vignette illustrating a facilitator's interaction with a small group deciding on a testable hypothesis, and a handout with examples of in-the-moment "moves" and corresponding goals/aims in the context of promoting learner ownership, making learner thinking accessible, and creating an equitable and inclusive environment.

4.1.2 During the workshop

The workshop was structured so that the participant time consisted of a mix of discussion, collaboration, or individual reflection. It began with a brief introduction (less than 10 minutes) to review the workshop goals, the purpose of facilitation, and how we would accomplish the goals over the course of the two hours. The majority of the session was spent in some form of discussion (65 minutes). First participants were asked to form two groups (six individuals per group) to identify types of facilitation moves and missed moves in the context of facilitation goals; making learner thinking accessible, supporting learner ownership, or promoting equitable collaboration. Two vignettes were chosen to represent the types of interactions instructors might encounter during the week. The different scenarios provided fodder for discussion (45 min total); one presented a small group interaction to discuss group dynamics and this was provided as pre-reading material, the other a one-on-one mentoring interaction and was provided as a handout. After vignette discussions, participants were given a choice to take a break and/or take time to reflect on how they may address facilitation goals or address a challenging scenario of their own activity. After working on their own for about 10 minutes, participants created small groups of four to brainstorm, troubleshoot, and/or design through a challenging scenario, to address one of the facilitation goals (~20 min). The workshop closed with the group coming together for a brief synthesis and wrapping up with any final thoughts (~10 min).

4.1.2 After the workshop

Instructors taught their activity and were asked to complete a short survey on whether they used facilitation moves, and if so, which ones. This provided workshop facilitators one final glimpse at learner thinking (and post-teaching) culminating assessment. A little over half of the participants completed the post-teaching survey (62%), and of those, all used facilitation moves on student learners in the context of at least one facilitation goal discussed in the workshop.

4.2 Discussion vignettes as curriculum tools and facilitation tools

4.2.1 Discussion vignettes as part of the curriculum

Vignettes that were chosen to illustrate the types of interactions instructors could expect to encounter during their week of experiential teaching were great tools for discussion. They presented to the discussion group the same scenario to apply facilitation strategies while allowing for individual interpretation. Specifically, the vignettes chosen illustrated how small moment-to-moment interactions (“moves”) can impact the experience of the learner. Thus serving as a crash-course in applying facilitation strategies. Also, by identifying and discussing both verbal and non-verbal moves, vignettes were used to highlight that moves can be intentional, especially if the facilitator is aware, is assessing, and can respond with an appropriate “move” to address a facilitation goal.

4.2.2 Discussion vignettes as a tool to facilitate broader points

The vignettes provided a way for the discussion facilitator (me) to observe the instructor group dynamics (e.g., dominant speaker, gender balance, cultural differences, etc.) to support equitable and inclusive discussion, make learner thinking accessible, and help maintain ownership. To illustrate this, the following are broad examples of facilitation strategies that were used to bring the discussion back to the learning goal when a viewpoint was brought up with a potential for many avenues of discussion.

4.2.2.1 Learning goal: Observing group dynamics to support equitable and inclusive discussion

Although the workshop’s participant gender ratio was six women to six men (50% women), my vignette discussion group consisted of five men to one woman (17% women). I believe the gender imbalance (heavily male dominated) initially led to a discussion that completely ignored alternative interpretations from a female minority lens. Interestingly, the only female in our discussion group was the one to point out an alternative viewpoint. She drew parallels to the group’s gender imbalance, female minority, to the vignette being discussed where a gender imbalance was not explicit, but could be possible — the facilitator in the scenario was not presented as male or female and was assisting a female student and a male student. Instead of disregarding the observation as one that was not explicitly presented (female minority situation), I used the opportunity to move the group discussion towards considering the alternative view expressed. Specifically, by identifying a dominant team member and how that might play a part in the possible behavior women and people of color have experienced in male-dominated spaces, such as women’s ideas presented in the group being ignored until they are taken up by a male colleague (ref?). Awareness can play a role in assessing the group dynamics and to choose a facilitation move to balance (or counteract) the group balance to make it inclusive.

This part of the group discussion also points out that individuals bring with them their own perspectives and experiences when assessing a situation of group dynamics. Being aware of their own viewpoints, or possible blindspots, are useful in choosing an appropriate facilitation move, assessing, and adjusting.

4.2.2.2 Learning goal: Making learner thinking accessible

Prompts used were aimed at helping participants vocalize the facilitation moves they recognized, identified (with), or felt were missing. One prompt, in particular, was aimed at having participants connect a facilitation move to the possible/ resulting impact that move could have on a facilitation goal, such as the student's feeling of ownership over the learned material ("I figured it out"). Thus trying to move the group to understand that facilitation strategies could be intentional with intentional results. A majority of participants in my group were able to identify a facilitation move with a goal, such as, dealing with a dominant group member to create an inclusive learning environment. However, by prompting different group members for their thoughts, instead of only hearing one answer and moving on, at least one participant expressed a differing valid sentiment. They felt that "these are just interactions with the learner. How are these strategies? Aren't they natural?" This provided an opportunity for me as a facilitator to gauge if the learning goal was coming across. In this case, the learning goal was that making small moves, such as asking an open-ended question, or kneeling down to the level of a student to be at eye-level, are facilitation "moves" that can be intentional toward achieving a goal. By opening the discussion on a thought that seemed intuitive, and asking participants to make the connection to the concepts presented in the handouts, there was an opportunity to express the thought above, assess learner's thinking, and choose a way to facilitate discussion toward the learning goal.

Proper preparation before facilitating a discussion, such as making notes of alternative interpretations to spur discussion, creating balanced groups beforehand, and providing proper contexting, can go a long way in nurturing a rich discussion while smoothly facilitating the group toward the learning goals.

4.3 Positive small group collaboration to maintain ownership and promote a supportive inclusive community

After discussing facilitation strategies applied to general scenarios in vignettes, participants were asked to apply these facilitation strategies to the activity they would lead in the upcoming summer school. This was intentional to transfer the ownership of facilitation moves to instructors, by "making it their own" (Ball et al., 2022). This was done in small groups of four so strategies could be brainstormed among the group to build community among instructors. As a facilitator I mostly stayed quiet, except to reinforce a positive idea, to allow for participants to collaborate. The goal was to encourage a positive experience and sense of community so instructors would be comfortable in seeking help from each other. Another aim was to encourage a positive experience and sense of community so instructors would be repeat-instructors (instructor alumni) to the summer school.

4.4 Conclusion on setting the tone

Facilitating can be tricky and can require some trial and error. For discussions, one tip I have learned through the PDP has been to set expectations of the facilitator's role ahead of time to the group. Generally speaking, this can be different from other group discussions that participants may be familiar with. For example, before beginning, I briefly state the discussion norms and my role as a facilitator in the upcoming discussion. It establishes that the facilitator has a very targeted role throughout the activity, and explicitly asks participants to engage in self-monitoring, be respectful, and take an active role to progress the activity goals. Particularly useful when participants are about to embark on a topic that evoke strong feelings or reactions, but also when preparing students to take part in challenging inquiry-based activities meant to promote growth mindset. Establishing these simple expectations and ground-rules sets the tone of the group, maybe learners anticipating a silent facilitator are more secure when awkward silences are encountered or get stuck in a challenging activity. It gives me as the facilitator the freedom and flexibility to decide to be more heavy handed (directed), if needed, or nuanced contributor. As a facilitator it removes the pressure of leading the group, but creates a more forgiving role as group guide. When I have not set these expectations, it can be difficult for me to direct the group back to targeted discussion points without it feeling abrupt. A more skilled conversationalist may navigate this well, but for me, setting up the possibility that I may do this helps us to quickly move past the awkward feeling.

5. Conclusion

In this paper we have explored the importance of facilitation in the development and realization of inquiry based activities through three specific examples: a physics classroom, an engineering program and an instructor training session. In all of them the key aspects of inquiry are fundamental pillars of the facilitation process. We have identified that the role of the facilitator is crucial for the success of the learning process and as such it is very important to define that role from the very beginning of the design of the activity including possible facilitation scenarios that may arise.

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