**Problem Solving Session Insights**

**AAU STEM @ Brown**

The information in this instructional resource comes from a culmination of three academic years of research experiences in introductory STEM courses at Brown University. Each section answers a question about a particular aspect of designing a course to include problem solving sessions with insights from the STEM education literature as well as instructors at Brown. *Problem solving sessions* are course meetings that focus on discussion, teamwork, and challenging STEM students to reach their academic potential in a supportive, facilitated environment. During the average problem solving session, ~20 students work through a *session* *activity packet* consisting of ~5 conceptual, context-rich problems that encourage conversation and exploration in teams, while ~2 facilitators circulate the room to answer questions and provide targeted guidance to help students persist through challenging material. Instructors at Brown have incorporated problem solving sessions both as replacements for standard recitation/ conference/discussion sections and as optional additions to the existing structure of their courses. In either case, problem solving sessions provide an invaluable opportunity for students to build self-confidence and a sense of community as they develop as scientists at Brown.

**What goes into implementing problem solving sessions in a course?**

This instructional resource organizes the implementation of problem solving sessions into three components: 1) the structure and organization of the sessions, 2) staff and training, and 3) iterative evaluation. The description of each component is broken down to provide the *pedagogical framing* from the STEM education literature, *AAU STEM suggestions* that summarize the research findings at Brown, and actual *examples from Brown* that instructors have found successful. Before each topic is explored in detail, an example timeline of implementing problem solving sessions in a course is provided in Figure 1 to orient the reader.

Figure 1. Gantt chart of problem solving session implementation

**1. What do problem solving sessions look like?**

The short answer is that problem solving sessions can take on many forms, as long as students feel accountable for attending and have the opportunity to work together with their peers to solve problems.

**1.1. Student Accountability**

Pedagogical framing: *Seat time cannot be fully replaced by out-of-class time, and students take cues from incentives about the importance of seat time.*

AAU STEM suggestion: Show students that problem solving sessions are an important part of the course by offering appropriate incentives.

Examples from Brown

* In PHYS0050/0060, attendance at problem solving sessions is voluntary. However, students are promised that at least one question on each exam will be an exact copy of one of the questions from the preceding problem solving sessions (generally 1 out of ~20 questions). Consequently, attendance is usually above 50% despite being voluntary.
  + Pro: instructors do not have to take attendance or grade participation
  + Con: attendance is generally lower than that of mandatory problem solving sessions
* In PHYS0030/0040, attendance to problem solving sessions is mandatory and graded. However, attending is not enough to earn full points, and students are instead graded on their participation during the session. For example, one session format required each student to present a solution to at least one of the session problems to a facilitator to earn their participation points.
  + Pro: both problem solving session attendance and participation are generally high
  + Con: facilitators must carefully observe all students to assign participation grades fairly
* In CHEM0100, attendance to problem solving sessions is mandatory and graded using a quiz at the end of each session.
  + Pro: attendance is generally high during problem solving sessions
  + Pro: instructors have tangible evidence of what students have learned
  + Con: instructors must grade quizzes
  + Con: some students skip the bulk of each session to show up just for the quiz

**1.2. Student Teams**

Pedagogical framing: *Collaborative learning experiences improve student outcomes by building community and situating student learning in a broader context than the self, but must be carefully structured for maximum benefit.*

AAU STEM suggestion: Have students work in teams of three (randomly assigned with no isolated women or URM students) and encourage them to work with the same team members over multiple sessions.

Examples at Brown

* In PHYS0050/0060, students are allowed to self-form their teams. However, they are encouraged to form teams of three and work with the same team members over multiple sessions. Although attendance is voluntary, instructors ask students to sign in and keep track of team formation during each session.
  + Pro: instructors do not have to assign teams
  + Con: instructors have less control over team formation than if they assigned teams
* In CHEM0330, students are assigned to random teams of three and work with the same team over the entire semester unless they opt for their team to be reformed midway through. Instructors ask students to sign in and keep track of team attendance during each session.
  + Pro: instructors have full control over team formation
  + Con: instructors must carefully assign teams and avoid isolating women and URM students

**1.3. Session Activity Packets**

Pedagogical framing: *In their progression from novice to expert, students gain confidence and build trust in themselves through experience with estimation, uncertainty, and collaborative problem solving.*

AAU STEM suggestion: Structure session activity packets such that they reinforce teamwork and help students engage more deeply with the material than plugging numbers into equations.

Examples at Brown

* In CHEM0100/0330, session activity packets have structured questions that include a space for estimation and uncertainty. On quantitative questions, students are asked to estimate both the order of magnitude and the units of the answer before making any calculations. On qualitative questions, students are asked to write their first thoughts before discussing with their group. As a summative exercise, students are also asked to reflect on which question they felt they understood best and which question they were still most uncertain about.
* In APMA0350, session activity packets include explicit steps within questions which ask students to explain to a facilitator their thought process so far (i.e., before arriving at a final solution). These mid-question checks require students to not only be able to map out where they have been, but also predict where they are heading as they engage collaboratively with the material.
* In PHYS0030/0040, session activity packets are handed out as a series of individual questions to address pace differences between team members. Teams must complete each question together and demonstrate that all team members feel comfortable with the solution before they receive the next question from the facilitator.
  + Because sessions are mandatory, the full solutions to the session activity packets are posted online for students to access before exams.
* In PHYS0050/0060, session activity packets are color coded by question such that facilitators can simply look around the room to visually confirm that all members of a team are working on the same problem. If a team member is either ahead or behind the rest of their team, facilitators can step in to address the pace difference efficiently.
  + Because sessions are voluntary, full solutions to the session packets are never posted. Instead, students must attend a session for an opportunity to generate the solutions themselves. To ensure students leave sessions with correct solutions, facilitators check every completed question before the end of the session.

**2. Who is staffing the course?**

Once the policies, resources, and space for your problem solving sessions are decided, the next step is to staff the sessions. In the same way that the sessions themselves can be implemented in a variety of effective ways, they can also be staffed to match the structure and budget of the course.

**2.1. Sustainable Training**

Pedagogical framing: *A “train-the-trainer” model builds institutional capacity for future training, spreads expertise across departments, and contributes to sustainability of the project work.*

AAU STEM suggestion: All new instructors attend small group facilitation training led by past instructors during the first week of the semester.

**2.2. Required Staff**

Pedagogical framing: *During collaborative learning experiences, students need enough guidance to progress without becoming frustrated to the point of “burning out.”*

AAU STEM suggestion: Staff each course with enough facilitators for a ratio of one to every three teams in each session if possible, and avoid assigning more than ten teams to any single facilitator during a single session.

**2.3. Communication**

Pedagogical framing: *Facilitators need ongoing training and support to provide effective guidance to students and address challenges as they occur.*

AAU STEM suggestion: Instructors hold weekly meetings to discuss how problem solving sessions are progressing and any ongoing challenges that need to be addressed by facilitators.

**3. How is the course going?**

Instructors often ask themselves how their hard work is translating to student outcomes, and how those student outcomes can be used to make iterative improvements to their course. The list of examples included here are just a sampling of all the possible evaluation methods available to instructors.

**3.1. Confidence Surveys**: Students are asked how confident they are in their abilities to solve problems related to key concepts they should know at the end of the course.

* AAU STEM suggestions:
  + Online
  + Identity-linked for metacognitive correlation with performance on concept inventories/exams
  + Pre-test during week 2 or 3 and post-test during week 11, 12, 13, or 14
  + No credit or “If at least 80% of students complete the survey, 100% get extra credit” model
  + Note: Primary instructor must identify key concepts students should know at the end of the course before confidence surveys can be created/selected.

**3.2. Social Belonging Surveys**: Students are asked about their comfort and sense of belonging in the course.

* AAU STEM suggestions:
  + Online
  + Anonymous except for optional gender/race/ethnicity self-identify questions
  + Post-test during week 11, 12, 13, or 14
  + No credit or “If at least 80% of students complete the survey, 100% get extra credit” model

**3.3. Concept Inventories**: Students are asked to solve problems related to key concepts they should know at the end of the course.

* AAU STEM suggestions:
  + Face-to-face on paper
  + Identity-linked for metacognitive correlation with responses to confidence surveys
  + Pre-test during week 2 or 3 and post-test during week 11, 12, 13, or 14
  + No credit or “If at least 80% of students complete the survey, 100% get extra credit” model
  + Note: Primary instructor must identify key concepts students should know at the end of the course before concept inventories can be created/selected.

**3.4. Mid-semester feedback**: Students are asked to provide formative feedback to instructors about midway through the course.

* AAU STEM suggestions:
  + Online
  + Anonymous except for optional gender/race/ethnicity self-identify questions
  + During week 6 or 7
  + No credit

**3.5. End-of-semester feedback**: Students are asked to provide summative feedback to instructors at the end of the course.

* AAU STEM suggestions:
  + Online
  + Anonymous except for optional gender/race/ethnicity self-identify questions
  + After final grades have been input
  + No credit

**Appendix A. Feedback Question Bank**

* What about the course is MOST helpful to your learning? (paragraph response box)
* What about the course would you CHANGE to make them more helpful to your learning? (paragraph response box)
* What about workshops/conferences/problem solving sessions is MOST helpful to your learning? (paragraph response box)
* What about workshops/conferences/problem solving sessions would you CHANGE to make them more helpful to your learning? (paragraph response box)
* Which topics covered during the workshops/conferences/problem solving sessions were MOST helpful to your learning? (paragraph response box)
* Which topics covered during the workshops/conferences/problem solving sessions were MOST helpful to your learning? (paragraph response box)
* How often your team is visited by a facilitator during problem sessions is:
  + too much. Please give us some space to work.
  + about right. They are there when we need them.
  + too little. We are left waiting often.
  + Please describe your reasoning for selecting a), b), or c). (paragraph response box)
* Please provide any additional comments or suggestions not addressed by the other questions. (paragraph response box)
* For sessions with graded participation: How often do you feel that you are attending workshops/conferences/problem solving sessions primarily because you receive course credit for doing so? (rated: Always – Never)
* For what reasons do you attend workshops/conferences/problem solving sessions? (paragraph response box)
* What can you, AS A STUDENT, do to improve your learning in the course? (paragraph response box)
* What tips do you have for future students interested in taking this course about successfully working in teams? (paragraph response box)
* What tips do you have for future students about being successful in this course? (paragraph response box)
* How much time (in hours) do you spend outside of class preparing for workshops/conferences/problem solving sessions? (fill in the blank box)
* How do you prepare for workshops/conferences/problem solving sessions? (paragraph response box)
* How much time (in hours) do you spend outside of class studying for this course? (fill in the blank box)
* How do you study for this course? (paragraph response box)
* I discussed the session problems with students from OUTSIDE of the workshops/conferences/problem solving sessions. (rated: Always – Never)
* How would you rate your study skills for this course? (rated: Excellent - Poor)
* What is your intended concentration? (fill in the blank box)
* What is your self-identified gender? (fill in the blank box)
* What is your self-identified race? (fill in the blank box)
* What is your self-identified ethnicity? (fill in the blank box)
* Are you a pre-med student? (Yes/No)
* How confident are you in your understanding of the material in the course? (rated: Very confident – Not at all confident)
* How confident are you that you can use what you are learning in this course for your future coursework? (Very confident - Not at all confident)
* Which workshops/conferences/problem solving sessions have you attended? (checkbox with time/day options)
* How many workshops/conferences/problem solving sessions have you attended? (fill in the blank box)
* During how many workshops have you worked with the same team members? (fill in the blank box)
* I felt attending workshops/conferences/problem solving sessions was helpful to my learning. (rated: Always – Never)
* I felt working in teams was helpful to my learning. (rated: Always – Never)
* I came on time to workshops/conferences/problem solving sessions. (rated: Always – Never)
* If this course were a swimming pool, I am:
  + breaking swimming records!
  + swimming with ease.
  + swimming with some difficulty.
  + barely treading water.
  + drowning.
* How much knowledge do you feel you are gaining from this course? (rated: Very much - Very little)