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INSTRUCTOR CHECKLIST – PROBLEM SOLVING

This checklist provides recommendations for choosing and assessing problem-solving approaches, combined with brief descriptions of how to use the pedagogies reviewed in the accompanying guide in the LSE Feature: Evidence Based Teaching Guide.

INSTRUCTIONAL CHOICES

☐ Employ backwards design to determine which approaches are most appropriate. There are pros and cons to any pedagogy; your aim is to find a strategy that aligns with your objectives and course context.

- Evaluate students' background knowledge and current skill level. It remains an open question how prior knowledge should influence instructional choice, i.e., whether less knowledgeable students always benefit from less demanding approaches or increased guidance. Nonetheless,
  - Assessing prior knowledge can reveal student thinking and therefore guide instruction.
  - Identifying the ways students think about science concepts may suggest a course of action.
- Optimize cognitive demands on students. For example, task instructions should minimize unnecessary cognitive demands, so students can focus on key features and general principles.
- If you're interested in students being able to solve problems with well-defined procedures, consider instruction-first approaches. Instruction-first approaches allow students to learn procedural steps efficiently.
- If your objectives emphasize learner agency, consider problem solving-first approaches. Problem solving-first approaches allow learners to actively explore evidence and invent solutions. They can instill a sense of ownership and foster learning (vs. performance) goals.
- If your objectives emphasize self-regulation, consider problem solving-first approaches. Problem solving-first approaches are especially effective for enhancing students' self-direction and preparedness for future learning.

☐ Provide opportunities for students to exchange ideas and co-construct knowledge. Collaborative work can improve learning outcomes, student engagement, self-management, and teamwork skills.

☐ Emphasize discourse in group work and class discussions. To maximize the benefits of problem solving, prompt students to explain their reasoning, justify their answers, and name or describe the general principles they abstract from problems.

☐ Incorporate variation in the problems you use. Providing positive and negative cases (i.e., where the phenomenon is present vs. absent) and guidance can help students identify general solutions.

Option: Instruction-First Approaches

You might choose instruction-first approaches if learners are very new to a domain. These approaches can help manage students' cognitive load, allowing them to focus on key features and identify general principles. Brief guidance is provided for two approaches: worked examples and peer-led team learning.

Worked Examples

Key characteristics:

- A problem statement and step-by-step procedure showing how an expert might solve it.
- Lessons include 2+ examples per problem type, to encourage comparison and self-explanation.
- Examples interspersed throughout direct instruction and accompanied by practice problems.

Useful when:

- Novices are learning to solve complex problems, but not for expert learners or for simple problems. Worked examples can become redundant with knowledge during later stages of skill acquisition.

Benefits:

- Near transfer is improved when instruction is followed by worked examples and practice problems compared to instruction followed by problem solving only.
- Reduced cognitive load helps students recognize important problem and solution features.

Guided Inquiry: Peer-Led Team Learning (PLTL)

Key characteristics:

- Students collaboratively reason and problem solve in groups of 6-10 for 90-120 minutes/week.
- Sessions are facilitated by trained peer leaders, who are closely supervised. Peer leaders do not provide answers; students must collaboratively assess their own work.
- Weekly problems are written by the instructors, requiring students to apply concepts they have learned in class and becoming more complex as the problem set progresses.

Useful when:

- Departments have resources to train, supervise, and compensate peer leaders and are supportive of innovative teaching.
- Instructors are closely involved in organizing and integrating the program with the course.
- Problem-solving activities are appropriately challenging, encourage collaboration, and require deep engagement with content.

Benefits:

- Improves achievement, retention, problem-solving skills, and communication abilities.
- Facilitates learning, interpersonal skills, leadership, and confidence of peer leaders.

Option: Problem Solving-First Approaches

You might choose problem solving-first approaches if your goals emphasize learner agency and self-regulation skills. Brief guidance is provided for three problem solving-first approaches: process-oriented guided inquiry, contrasting cases, and productive failure.

Guided Inquiry: Process-Oriented, Guided-Inquiry Learning (POGIL)

Key characteristics:

- Students work in collaborative groups of 3-4 during class, with instructor facilitation and rotating student roles to foster interdependence
- Replaces lecture with a combination of guided-inquiry learning and process skill (e.g., communication, self-assessment, information processing) development.
- Structured activities follow a 3-stage learning cycle: exploration, concept-invention, and application.

Useful when:

- Instructor has access to structured guided-inquiry activities or resources to create their own.
- Instructor is prepared to facilitate group inquiry rather than leading lecture.

Benefits:

- Improves achievement, retention, and process skills compared to lecture-based instruction.
- Focus on process skills and collaboration develops professional readiness and accountability.

Contrasting Cases

Key characteristics:

- Problems or scenarios that differ in key features, with the aims of (a) inventing a general solution or (b) identifying case similarities and differences.
- More guidance leads to greater benefits from contrasting cases.

Useful when:

- Can be used before or after direct instruction, but benefits appear larger when cases are explored before introduction of the underlying principle.
- In both individual and cooperative learning environments.

Benefits:

- Case comparisons help learners identify deep features of a problem type and develop conceptual understanding about solving problems in the target domain.
- Contrasting cases prior to instruction reduce extraneous cognitive load and increase learning.

Productive Failure

Key characteristics:

- Phase 1: Students independently solve complex problems that are beyond their capabilities.
- Phase 2: Direction instruction on normative conceptual knowledge and problem-solving procedure, incorporating student-generated solutions from phase 1.

Useful when:

- Class culture normalizes exploration and mistakes as productive parts of learning.
- Students are encouraged to draw on prior knowledge and connect between concepts.
- Instructor is comfortable integrating student ideas and errors into their direction instruction.

Benefits:

- Failure during problem solving can activate and reveal gaps and limits of prior knowledge.
- It also increases learner agency and motivation, preparing students for future learning.

ASSESSMENT CHOICES

☐ <u>Determine what degree and type of transfer you expect successful students to demonstrate</u>. Assessment problems may be relatively similar (near transfer) or different (far transfer) from those encountered while learning. They can also differ from instruction along many dimensions, e.g., knowledge domain, the skill learned, memory demands, etc. Identifying assessment goals may help you design transfer tests that measure intended knowledge and skills while holding other details constant.

☐ <u>Discuss students' learning strategies and encourage abstraction as preparation for transfer</u>. Individual students differ in their tendency to memorize example problems (exemplar learners) or deduce underlying patterns across problems (abstraction learners). Both strategies can produce similar retention and near transfer, but abstraction improves far transfer.

☐ <u>Consider assessing cognitive and affective outcomes beyond transfer</u>. Based on your learning objectives, you may expect your course to improve less traditional student outcomes like interest, confidence, or creativity. Brief surveys or reflections can detect student growth on these outcomes and are often easily incorporated into existing course structures. If you need help choosing assessments, contact your institution's teaching center or consult with discipline-based education researchers.