HOW TO HELP YOUR STUDENTS BECOME SELF-DIRECTED LEARNERS*

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Reference: R.M. Felder & R. Brent, *Teaching and Learning STEM: A Practical Guide.* Jossey-Bass, (2016). **(TLS) < https://educationdesignsinc.com/book >**

INTRODUCTION

Instructors and employers of engineering students commonly complain about what the students and recent graduates cannot do. "All they know how to do is memorize!" grumble the professors. "I may go over a problem in class, but if I give them a slightly different problem on an assignment or test, they're helpless." "That's right," agree the employers. "If they get an assignment on the job that isn't exactly like something they were taught in school, they have no idea what to do."

Whether or not the professors and employers use the term, they are bemoaning the fact that their students and new employees are not *self-directed learners,* able to tackle a new problem and figure out what they need to learn to solve it, where to get the necessary information, and how to work their way to a solution, all without professors and textbooks.

It should not come as a surprise to the instructors that many of their students can't do those things, because K-12 and college courses rarely teach how to do them. Some students are naturally talented and learn how on their own but most don't do it in school, and they either do it through painful trial-and-error after graduation or they never learn.

The skills needed to be a self-directed learner are not obvious to most students, but they are not very difficult to teach. This webinar will outline several of the most important skills and how to teach them, addressing the following questions:

- What is self-directed learning? What do self-directed learners do that most students don't do?
- How can engineering students who are not self-directed be introduced to the concept, motivated to develop the required skills, and started on the path toward doing so?
- How can development of self-directed learning skills be integrated with traditional STEM instruction (which is how the skills are most likely to be learned) rather than being treated as a separate topic?

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DEFINITION AND CHARACTERISTICS OF SELF-DIRECTED LEARNERS

Self-directed learning: Individuals organize and manage their own learning needs and activities.

What self-directed learners do:

1. Clearly define nontrivial problems
2. Think outside the box
3. Make decisions based on logic and evidence
4. Reflect on what they're doing and how it's working

What successful professional engineers, scientists, and entrepreneurs do:

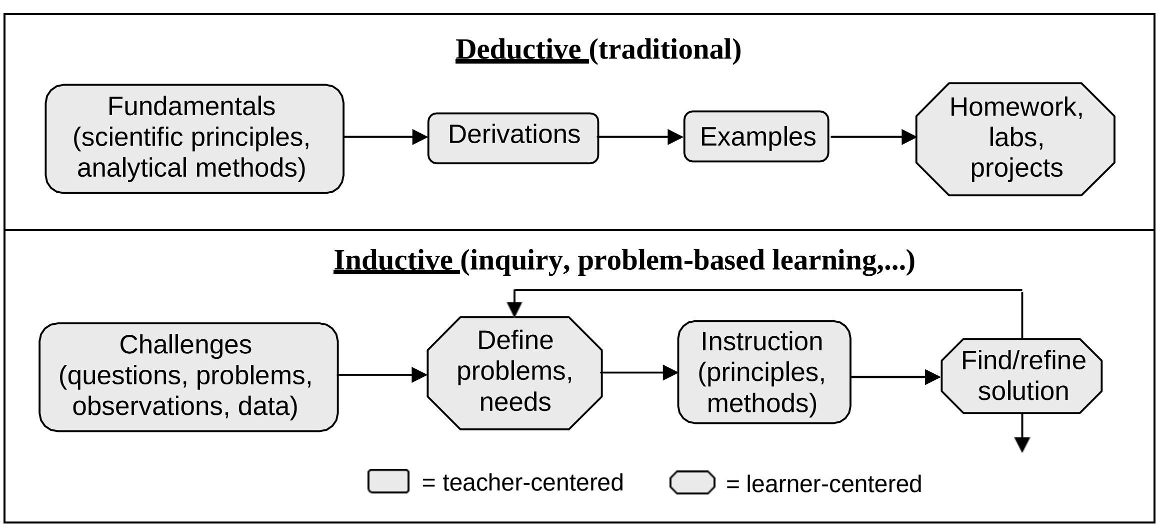
The same things self-directed learners do.

What instructors need to do to produce self-directed learners:

1. Clearly define nontrivial problems → *Use inductive teaching* (TLS, pp. 207-209, 238–239, 272, 279–283)
2. Think outside the box → *Teach creative thinking* (TLS, 222–230)
3. Make decisions based on logic and evidence → *Teach critical thinking* (TLS, pp. 230–235)
4. Reflect on what they're doing and how it's working → *Teach metacognition* (TLS, pp. 191–194), and to be successful at any of those tasks
5. Provide the students with adequate *challenge* and *support* (TLS, pp. 235–241)

Items 1, 3, and 5 will be discussed in this presentation. Information about all the items is given in the above references.

INDUCTIVE TEACHING AND LEARNING



Course topics and entire courses can be taught

- Deductively — start with principles, deduce & derive methods & applications. Traditional in science and engineering education. Efficient at promoting short-term retention of information.
- Inductively — start with challenges, introduce principles and methods on a need-to-know basis in the context of the challenges. Various forms—inquiry-based learning, problem- based learning, project-based learning, case-based instruction, just-in-time teaching. Research → More effective at promoting conceptual understanding, long-term retention, transfer.

- Deductive presentation does not convey a sense of how science, engineering, and learning in general really happen. Inductive presentation does.

Features of common inductive instructional methods*

Method → Feature ↓	Inquiry	Problem-based	Project-based	Case-based	Discovery	JiTT
Questions or problems provide context for learning	**1**	2	2	2	2	2
Complex, ill-structured, open-ended real-world problems provide context for learning	4	**1**	3	2	4	4
Major projects provide context for learning	4	4	**1**	3	4	4
Case studies provide context for learning	4	4	4	**1**	4	4
Students discover course content for themselves	2	2	2	3	**1**	2
Students complete conceptual exercises electronically; instructor adjusts lessons according to responses	4	4	4	4	4	**1**
Primarily self-directed learning	4	3	3	3	2	4
Active learning	2	2	2	2	2	2
Collaborative/cooperative (team-based) learning	4	3	3	4	4	4

1 – by definition, 2 – always, 3 – usually, 4 – possibly

* M.J. Prince and R.M. Felder, "Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases," *J. Engr. Education, 95*(2), 123–138 (2006), <*https://tinyurl.com/2006-InductiveTeaching*>

Why teach inductively?

Teachers unfamiliar with inductive learning are understandably nervous about challenging students to do something before they've been taught to do it. Here are several reasons for doing it.

- Traditional deductive instruction (teacher presents something, students copy and memorize it and try to reproduce it on assignments and tests) leads to very little meaningful learning of difficult concepts and methods. Confronting students with reasonable challenges up front (*desirable difficulties*) motivates them to learn and promotes learning. Even if they can't figure out how to meet a challenge on their own, they're much more likely to get it when the instructor presents and explains the solution.
- For most inductive methods (such as inquiry-based instruction), the challenges are low-stakes. The students struggle fairly briefly and then get affirmation or corrective feedback. Those brief struggles can help them avoid much greater struggles on assignments and tests.
- Mountains of research have demonstrated that inductive teaching works better than traditional (deductive) instruction.

Inquiry-Based Instruction

Any inductive teaching method that does not fall into any of the other categories in Columns 3–7 of the above table can be called inquiry-based instruction (aka inquiry-based learning, inquiry-based science, guided inquiry, or just inquiry). To teach with an inquiry-based approach, keep the following suggestions in mind:

- Introduce each major course topic with a challenge (an open-ended question to be answered, a problem to be solved, a set of observations or experimental data to be explained, or a case study or dilemma to be worked through).
- *Choose the appropriate level of teacher guidance*. If you are teaching students who have never been taught using an inquiry-based approach, provide extensive modeling and guidance at every step of the instruction; as the students gain more experience, move increasingly toward just setting the stage and getting out of their way.

Where can you find appropriate opening challenges for inquiry-based instruction?

- *Take a problem from the course text or from an old homework assignment or exam.* Choose a problem—preferably one with real-world connotations to increase motivation—whose solution requires knowledge of the next body of material you plan to cover (a section, a chapter, several chapters, or the entire text).

- *Pose an open-ended question or assignment*.
  - Given a description of a troublesome real-world situation, (a) define the problem, (b) summarize known information and what more is needed to solve the problem, (c) outline where to begin.
  - Predict (a) the outcome of a given procedure, or (b) the response of a given system to input changes, or (c) what might happen if…. Justify your prediction.
  - Given a proposed design or procedure submitted by someone in the department you head, recommend whether you should give it the go-ahead, reject it, or obtain more information. Justify your recommendation.
  - Design (or design and carry out) an experiment to measure____.
  - Explain the following (experimental result, observed natural phenomenon).
  - A process or product or procedure was designed to___, but instead it has begun to____. Troubleshoot.

TEACHING CRITICAL THINKING

Critical thinking: Judging the quality, value, or validity of something (such as a product, process, or procedure) or the superiority of one alternative over others and justifying the judgment using evidence and logic.

Critical thinking challenges

- Select from among alternative (designs, plans, programs, derivations, interpretations of data,…) and justify your selection.
- Analyze a case study or ethical dilemma, recommend a course of action, and justify the recommendation.
- Assign a grade to a sample lab or project report and justify the grade.
- Critique an article or editorial (evaluate accuracy & persuasiveness, identify stated and hidden assumptions).

SUPPORTING STUDENTS FACING CHALLENGES

1. **Make expectations clear.** Give examples of good and bad responses to challenges. Get students to identify faults and suggest improvements.
2. **Start small.** For students new to inductive teaching, initially give challenges as active learning exercises. Gradually shift them to assignments and projects.
3. **Provide adequate feedback to responses.** Show how weak responses could have been improved.
4. **As students gain more experience, provide less guidance.**

FINAL SUGGESTION

Adopt new teaching methods gradually. Trying to do too much new at a time leads to student confusion, resentment, and pushback. Try only one or two new methods in a course. Give them a fair try—don't abandon a method if your first attempt doesn't go well. If after several tries it starts to work, keep using it; if not, consult the literature or an expert, and if it still doesn't work, drop it. Next semester, try another one or two methods. Your teaching will steadily improve from year to year, and that's all you need.

WORKSHOP FACILITATOR BIOGRAPHIES

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Dr. Brent is President of Education Designs, Inc., a consulting firm in Chapel Hill, North Carolina. She has more than 40 years of experience in education and specializes in staff development in engineering and the sciences, teacher preparation, and evaluation of educational programs at both precollege and college levels, and she has authored or coauthored roughly 120 papers on those topics. She holds a Certificate in Evaluation Practice from the Evaluators' Institute at George Washington University. Prior to entering private consulting, she was an Associate Professor of Education at East Carolina University where she won an outstanding teacher award. In 2014, Dr. Brent was named a Fellow of the American Society for Engineering Education.

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Dr. Felder joined the N.C. State University faculty in 1969. He is a co-author of the book *Elementary Principles of Chemical Processes,* which has been used as the introductory chemical engineering text by roughly 90% of all chemical engineering departments in the United States and many abroad, and he has authored or co-authored over 300 papers on chemical process engineering and engineering education. He has won numerous awards for his teaching, research, and publications, including the International Federation of Engineering Education Societies Global Award for Excellence in Engineering Education (first recipient) and the American Society for Engineering Education Lifetime Achievement Award in Engineering Education (first recipient).

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Drs. Brent and Felder are coauthors of *Teaching and Learning STEM: A Practical Guide* (Jossey-Bass, 2016, ***https://educationdesignsinc.com/book/***). Separately and together, they have presented over 500 workshops on effective teaching, course design, mentoring and supporting new faculty members, and STEM faculty development, on campuses and at conferences around the world. They co-directed the American Society for Engineering Education National Effective Teaching Institute from 1991 to 2015. Visit their company website—including a blog with their ideas on teaching and learning—at ***https://educationdesignsinc.com*** and their Facebook page at ***https://www.facebook.com/felderandbrent***.