Motivation

The truth:
Students learn less than what we try to teach them.

How much students learn depends on:
• them
• you
• interactions between them and you - in other words, the match between their learning style and your teaching style.

We can’t change them. (But we can work with them.)
We wouldn’t change you.
What we can control are styles of teaching.
Broad Questions:

What are some of the different ways that students take in and process information?

Which learning styles are favored by:
  • many students?
  • the teaching style of many professors?

What can we do in the classroom to reach a broad spectrum of learning styles?

Overview

- perception, acquisition, processing, and retention of information
- both cognitive and affective behaviors
- individuality
- maximal learning when instruction capitalizes on an individual’s learning style preferences - the “matching hypothesis”

Learning styles

There are several definitions of “learning style.”

Generally, these definitions include aspects of:
  • perception, acquisition, processing, and retention of information
  • both cognitive and affective behaviors
  • individuality
  • maximal learning when instruction capitalizes on an individual’s learning style preferences - the “matching hypothesis”
Index of Learning Styles: overview

Felder’s Index of Learning Styles [1]

- Relatively short questionnaire
- Specifically formulated with engineering students in mind
- Does not require professional scoring and interpretation
- Collected data/publications available [2]
- Dimensions well-suited for discussions of teaching as well as learning

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### Learning styles

<table>
<thead>
<tr>
<th>Visual</th>
<th>Verbal</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Pictures</td>
<td>• Spoken words</td>
</tr>
<tr>
<td>• Diagrams</td>
<td>• Written words</td>
</tr>
<tr>
<td>• Flow charts</td>
<td>• Formulas</td>
</tr>
<tr>
<td>• Plots</td>
<td></td>
</tr>
</tbody>
</table>

“Show me the systems you’re talking about.”

“Explain what’s going on inside the systems.”

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### Learning styles

<table>
<thead>
<tr>
<th>Active</th>
<th>Reflective</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Tends to process information while doing something active</td>
<td>• Tends to process information introspectively</td>
</tr>
<tr>
<td>• Likes group work</td>
<td>• Likes independent work</td>
</tr>
<tr>
<td>• May start tasks prematurely</td>
<td>• May never get around to starting tasks</td>
</tr>
</tbody>
</table>

“Let’s just try it out.”

“Let’s make sure we’ve thought this through.”
### Learning styles

<table>
<thead>
<tr>
<th></th>
<th>Sensor</th>
<th>Intuitor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focused on sensory input - what is seen, heard, touched, etc.</td>
<td>Focuses on ideas, possibilities, theories</td>
<td></td>
</tr>
<tr>
<td>Prefers concrete information: facts and data</td>
<td>Prefers more abstract information: theory and models</td>
<td></td>
</tr>
</tbody>
</table>

“How does this class relate to the real world?”

“All we did were plug-and-chug assignments.”

### Learning styles

<table>
<thead>
<tr>
<th></th>
<th>Sequential</th>
<th>Global</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can function with partial understanding</td>
<td>Needs to see the big picture</td>
<td></td>
</tr>
<tr>
<td>Makes steady progress</td>
<td>May start slow and then make conceptual leaps</td>
<td></td>
</tr>
<tr>
<td>Good at detailed analysis</td>
<td>Good at creative synthesis</td>
<td></td>
</tr>
</tbody>
</table>

“I need to focus on one part of the project and get it done - then I can move onward.”

“I need to see how this all fits together before I can start the project.”

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What we’re not saying

We don’t mean to “put people in boxes.”

Everyone learns both actively and reflectively, both visually and verbally, etc.

Most people, however, have some preferences (mild, moderate, or strong).

Origins of ILS domains

Sensor - Intuitior

- Carl Jung’s theory of psychological types: sensing and intuition modes of perception
- Myers-Briggs Type Indicator: sensors and intuitors as problem solvers
- Kolb’s experiential learning model: concrete experience and abstract conceptualization
Active - Reflective

- Myers-Briggs Type Indicator: extrovert and introvert
- Kolb’s experiential learning model: active experimentation and reflective observation

Origins of ILS domains

Concrete Experience
- Making something new

Reflective Observation
- Internalizing experience

Abstract Conceptualization
- Developing concepts

Active Experimentation
- Doing it

Feeling
- Doing

Watching
- Thinking

Kolb’s cycle

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Kolb’s and Felder’s models

Reflective
Sensor
Active
Intuitor
Reflective

Making something new
Developing concepts

Learning styles of students and faculty

Percent of Population

Visual
Active
Sensor
Global

Preferred Learning Style

83
62
17
75
88
52
25

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n=12 (faculty)
n=255 [3] (students)
Learning styles of engineering students

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Visual</strong></td>
<td>88</td>
<td>80</td>
<td>69</td>
<td>60</td>
</tr>
<tr>
<td><strong>Active</strong></td>
<td>62</td>
<td>69</td>
<td>53</td>
<td>59</td>
</tr>
<tr>
<td><strong>Sensor</strong></td>
<td>60</td>
<td>59</td>
<td>57</td>
<td>57</td>
</tr>
<tr>
<td><strong>Global</strong></td>
<td>52</td>
<td>33</td>
<td>28</td>
<td>28</td>
</tr>
</tbody>
</table>

Learning styles and gender

- **Males, Engr (n = 692)**
- **Females, Engr (n = 135)**

University of Western Ontario [7]

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Learning styles and gender

University of Western Ontario
Males, Engr (n = 692)
Females, Engr (n = 135, 16.3%)

Tulane University
Males, Engr (n = 129)
Females, Engr (n = 63, 32.8%)

Critical thinking

Concerns which have been noted regarding the use of the Index of Learning Styles:

1. Doesn’t predict academic performance. [8]
2. The matching hypothesis - just a hypothesis - is difficult to prove. [9,10]
3. Lacks statistical validation. [8]
4. The whole idea is basically useless. [11]
Some concerns regarding the ILS appear to arise from a misapplication of the inventory:

- It was not developed to enable predictions of academic performance.
- It was not developed as a selection tool to determine ‘who should be an engineer’.

Activities or tests which engage only one learning style may not illustrate the true potential or abilities of a group of students.

1. Predicting academic performance isn’t easy

We found little or no correlation between SAT score and cumulative GPA at the end of the sophomore year.

![Graph showing GPA vs. SAT score with R² = 0.16 for Tulane sophomores in Statics, all disciplines, n=98 [3]]
2. Testing the matching hypothesis

\[ B = f(P, E) \]

Behavior-person-environment paradigm leads to the idea of optimizing the instructional environment for optimal learning.

Testing the matching hypothesis is difficult - there are many learning style schemes to test, not all easily comparable to each other.

Meta-analyses \([9,10]\) have claimed that a majority of published studies support the matching hypothesis.

3. Validation study summary

We believe Felder’s ILS to be a useful, appropriate, statistically-acceptable tool for characterizing learning preferences and discussing teaching methods.

There is (as always) some room for improvement. We encourage others to test new questions, work on statistical validation - especially when the ILS is administered to large numbers of students at one time - and share their findings.

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Think for a second:

Do “traditional lectures” engage active learners?

Do “traditional lectures” engage reflective learners?

The traditional lecture format

The traditional engineering lecture format tends to be:

- Verbal
- Passive
- Intuitive
- Sequential

The majority of students tend to prefer learning:

- Visually
- Actively or Reflectively
- Sensory

In fact, the teaching style utilized in the traditional lecture does not even necessarily match the preferred learning styles of professors.
Good news:
Engaging multiple learning styles does NOT require complete restructuring of a course, or eliminating traditional lectures.

More good news:
Teaching methods that address styles short-changed by traditional methods (e.g. visual, active, global, and sensor) often accommodate multiple styles.

Teach to a student’s style? [14]

The matching hypothesis: teaching to a student’s learning style provides the best opportunity for learning.
- A student functioning in their preferred modes is focused on learning and not on overcoming a barrier.

However, should we teach to the strengths of the student, or work to help them develop in their areas of weakness (less preferred modes)?
- Students will need to be able to function in different modalities at different times, e.g. both actively and reflectively, both visually and verbally, etc.
With the diversity of learning styles in the classroom, do we teach to a single, preferred learning style? If so, which one?

- Teaching to a single, preferred learning style (or using a single style to teach) will benefit those few students who prefer that chosen style.

The best solution is likely to utilize a variety of instructional styles and modes of delivery in a course.

- Enable ALL of the students to function in their preferred modes some of the time, and also encourage development in less-preferred modes.

Consider targeting the largest mismatches.

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What is active learning?

Active learning can be defined as anything that requires students to engage the material and think about what they are doing

Although this would - in the strictest sense - include traditional activities such as homework, generally speaking, “active learning” is used to refer to elements that are introduced into the classroom - and contrasted with what is termed a traditional ‘lecture-only’ approach

After 2 weeks we tend to remember:

10 % of what we read
20 % of what we hear
30 % of what we see
50 % of what we hear and see
70 % of what we say
90 % of what we do and say

(Cone of Learning, Edgar Dale)
Active Learning

Any activities which require students to actively engage with and apply course material

Collaborative

A subset of active learning - activities which engage students in *interacting with each other* while they learn and apply course material

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A subset of collaborative learning - activities which engage students in interacting with each other and with course material, under structured learning conditions.

Cooperative learning

Students work in groups on structured learning tasks under conditions that meet five criteria:

1. Positive interdependence
2. Individual accountability
3. Face-to-face interaction
4. Appropriate use of interpersonal skills
5. Regular self-assessment of group functioning

Cooperative Learning is NOT:
- Students sitting around a table studying together
- Group projects with one/two students doing all the work
Relevant problems are introduced at the beginning and provide context and motivation for the learning. This approach:

1. Is always active
2. Is usually collaborative or cooperative
   and is distinguished by the fact that it typically
3. Involves significant self-directed learning

Problem-based Learning is NOT:
- Students working on problems, even if they provide the motivation for the learning (the self-directed 'test')

What types of major reasons might professors give for not using any kind of active learning exercises in their courses?
Active learning: concerns

**Time-consuming**

Lose Control of the Class

Unpredictability

Too much effort

“How will I cover the syllabus?”

“You can’t do that in the classroom, you’ll get terrible teaching evaluations.”
For the busy professor: active learning

Active and collaborative learning techniques require the least amount of preparation and scheduling, and can be constructed to take up minimal amounts of class time.

Take up formal cooperative learning when you are ready for a challenge and motivated to spend time revamping your course.

Active learning exercises - even short ones - help students with both active and reflective learning styles engage with course material.

Active learning exercises

- One-Minute
- Two-Minute
- Five- to Ten-Minutes
- Ten-Minutes and Up

- Keeping - and relinquishing - control of a group discussion.

- Sample hands-on and ‘minds-on’ active learning exercises and assignments that are not technologically demanding, and are adaptable to many levels of study.

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Information retention

![Graph showing information retention over time.]


Ultra-busy? 30-second/1-minute breaks

*For Individuals or Pairs*

Hand out copies of lecture notes which include _________ . As you lecture, take 30 - 60 seconds now and then for students to:

- Fill in blanks
- Check derivations
- Recall definitions
- List underlying assumptions
- Prioritize information

*One-Minute Essays*


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Mega-busy? Two-minute breaks

Think / Pair / Share
Informal Group Lists

• Make up two questions about the material
• Sketch and label a diagram showing . . .
• What’s wrong with what I just did?
• How could you check this solution?
• Sketch a plot of how the solution should look
• Which assumptions are necessary?
• What information is missing?
• What variations of this problem could I put on the next exam?

30 seconds! That’s too short!

Thirty seconds is a long period of silence in a classroom or public speaking venue.

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2 minutes? We won’t finish the exercise!

- Students *don’t have to* finish the exercise. Once minds are engaged, your goal is achieved. Students can finish the exercise later, as a study aid.

- You can circulate through the class, or not.

- Suggested format to take a 2-minute exercise and turn it into a 5-minute exercise:

  
  ![Diagram](https://via.placeholder.com/150)

  Individual

  Whole Group

  Small Group

Super-busy? 5- to 10-minute breaks

*Think / Pair / Share*
*Informal Group Lists*
*Group Worksheets*

Solving problems (or parts thereof)

  {variation on the theme: one person problem-solves out loud and writes, one person coaches the problem-solver but doesn’t write}

Sketching diagrams

Listing and justifying assumptions

Make a flowchart of problem-solving strategies

How does this topic link to...?

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Active exercises: group worksheets

Yes. **Worksheets.** Really. Like in grade school.

Work equally well for statics, or abstract theory, etc.

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Active exercise: group worksheets

- One sheet per group forces interaction.
- Making extra sheets (or solutions) available later for studying is kind.
- You can assign roles (or not), you can mix up the groups if desired.
- Sheets can be used to reinforce concepts, to lead students into new concepts, or to initiate open-ended discussions.
Group Worksheets
Guided Discussions

Research Abstracts:
(1 page, from meeting proceedings)
- Read and understand
- Question and critique
- Data analysis - discuss and verify conclusions
- Explain/interpret key figures
- Redraw key figures
- What should the researchers do next?

Research papers: Fifty-minute exercise!

Very busy? 10-minute breaks (and more)

Observations on discussions

- Pairs or groups of students are braver than individuals.

- Giving people time to think before expecting answers is generally a good idea.

- Telling students in advance that you will call on groups to share their thoughts helps motivate the activity.

- It’s OK for people to make mistakes. You may want to ask the class a few ‘stupid questions’ now and then.

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Active learning benefits

- Students cannot be ‘passive vessels’ - they must be engaged with the material
- Clearly informs instructor what students understand and what they don’t
- Shifts focus from professor to material (”sage on the stage” to ”guide on the side”)
- Increases and personalizes student-professor interactions
- Engages multiple student learning styles

Active learning: potential downsides

- Students cannot be ‘passive vessels’ - they must be engaged with the material *(sometimes all students want is to be ‘passive’)*
- Clearly informs instructor what students understand and what they don’t
- Shifts focus from professor to material
Make students your teammates

- Tell them what you are trying to do, and why.
- Tell them how an exercise is going to work before starting the exercise.
- Tell them when you gain a better understanding of their skills/knowledge through an exercise.
- Tell them when you are pleased with how an exercise works.
- Solicit feedback, and respond to it.

Our favorite feedback mechanism

Please write at least one thing that is working well for you. Please write at least one thing that could be changed.
Feedback

Seek and acknowledge student feedback.
Please take note of this phrasing.

Respond, don’t react.
Respond to issues to which you care to respond. Respond to something!
Include acknowledgments of “plus” issues as well as “delta” issues.
Even “I need to think about this for a bit; thank you for pointing it out,” is better than nothing.
Don’t take drastic measures unless they are clearly needed.

Feedback

Depending on the form (structured or unstructured), seeking formative feedback:

• Gives you information about what students are understanding and not understanding.
• Gives you ideas for potential improvements.
• Helps you understand how other factors may be impacting students’ attitudes and performance.
• Provides a venting mechanism so that issues don’t fester and become magnified.
Summary

Active learning:

- Can be applied at any level with minimal course change or scheduling.

- Provides a break in lecture, serves to renew student enthusiasm with material.  
  (and provides a rest for the instructor!)

- Gives immediate feedback on important concepts.

- Even occasional use can be very effective.

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Summary

Active learning exercises can be used to supplement lectures and to engage varied learning styles.

Active learning:
- does not have to require extensive preparation or class time,
- does not involve losing control of the classroom,
- will not lower teaching evaluation scores.
Does it work?

A longitudinal study of chemical engineering students has shown that courses designed to accommodate a spectrum of learning styles:

- increased students’ confidence in their academic preparation \(^{[15]}\)
- raised overall academic performance \(^{[16]}\) (even in subsequent courses taught “traditionally” by other instructors \(^{[15]}\))
- increased student retention \(^{[16]}\)
- increased graduation rate \(^{[15]}\)

Does it work?

The educational literature contains a wide variety of teaching techniques and ideas for engaging multiple learning styles. Many of these techniques do not require a significant amount of preparation time, and can be used to complement (not replace) traditional lectures.

Advice: Start small.
Work with visual/reflective/active learning first.
Tell students what you are doing and why.
Don’t quit after one try.
We thank:

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