Classroom Discourse Development for “Flipping Classrooms”: Theoretical Concepts, Practices, and Joint Efforts from Engineering Students and Instructors

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Purpose of the Study

- To support quality teaching for “flipping classrooms”
- To investigate fundamental roles of classroom talks in education and to advance our understanding of how engineering students learn through dialogic discussions and inquiries
- To help design better instructional approaches to shape classroom talks and learning

"language is the essential condition of knowing, the process by which experience becomes knowledge" - M.A.K. Halliday
Research Questions

(1) How does the implemented Four-Practice Instructional Model in “flipping classrooms” influence the classroom discourse development?

(2) In what ways does the development of classroom discourse impact student learning?

Research Settings and Methods

- In Electric Drive class with about 90 students enrolled each semester
- Total of 250 students participated in the study for the past three years
- Design-Based Methods that enable an iterative cycle for design, practice, research, test, and modifications of instructional interventions
- Data collection
  - Audio recording of students’ group talks
  - Group problem-solving worksheets and copies of students’ exam papers
- Revised educational taxonomy for discourse analysis
# Four-Practice Model for “Flipping Classrooms”

<table>
<thead>
<tr>
<th>Four-Practice Model</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>Anticipating</strong></td>
<td>• Problematizing content</td>
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<td></td>
<td>• Anticipate students’ learning demands</td>
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<td><strong>Monitoring</strong></td>
<td>• Giving students authority over their study</td>
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<td>• Probe students’ responses and engage in conversations with students</td>
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<td></td>
<td>• Keep group discussions on track</td>
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<td><strong>Connecting &amp; Contrasting</strong></td>
<td>• Holding students responsible to others and to norms of discipline</td>
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<td>• Elicit questions and encourage dialogic inquiries</td>
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<td>• Contrast students’ views to discipline norms</td>
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<tr>
<td><strong>Contextualized Lecturing</strong></td>
<td>• Providing relevant resources</td>
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<td>• Lecture based on students’ responses</td>
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Classroom Discourse Process Supported by the Four-Practice Model
Revised 2-D taxonomy for discourse analysis
Sample Discourse Patterns in Group Discussions

**Discourse Focus (Group O)**

- **Percentage (%)**
  - factual: 0%
  - conceptual: 80%
  - procedural: 0%
  - metacognitive: 0%

**Knowledge Type**

**Discourse Focus (Group T)**

- **Percentage (%)**
  - factual: 0%
  - conceptual: 80%
  - procedural: 0%
  - metacognitive: 0%

**Progression of Group Discussion Discourse**

- **Knowledge Type**
  - P: Procedural
  - C: Conceptual
  - F: Factual

**Transcription Line Number**

- 1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57
What leads to contrasting discourse patterns?

Possible causes:
• Group dynamics
• Content
• Others, for example how problems were framed
A close look at classroom discourse

Discourse Focus (Team-Problem 1) (a)

- Two groups working on the same two problems
- The top one did not generate talks around concepts

Discourse Focus (Team-Problem 2) (b)

- The bottom problem generated about 80 talking events, three times of the top one
- Talks concentrated on conceptual knowledge
Progression of Group Discussion Discourse
(Team-Problem 1)

Knowledge Type
M P C F

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

Group "WA"
Group "FL"

Progression of Group Discussion Discourse
(Team-Problem 2)

Knowledge Type
M P C F

1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73 75 77 79

Group WA
Group FL

M: Metacognitive; P: Procedural;
C: Conceptual; F: Factual.

Transcription Line Number
Q #1  
Magnetics

For the inductor shown below:
- The mmf available to push magnetic flux across the gap is 400 A-T
- One half of the gap area has a gap length of 1 mm, the other half has a gap length of 2 mm
- \( \mathcal{A}_{\text{core}} = 0.001 \, \text{m}^2 \)
- Assume infinite core permeability
- Assume the flux is vertical through the gap

Calculate the total flux in the core.

\[
\Phi_1 = \frac{1}{l} \frac{N M A}{l} \frac{dI}{dt} = \frac{(400)(4\pi \times 10^{-7})(0.001/2)}{0.001} = 2.51327 \times 10^{-4} \, \text{Wb}
\]

\[
\Phi_2 = \frac{1}{l} \frac{N M A}{l} \frac{dI}{dt} = \frac{(400)(4\pi \times 10^{-7})(0.001/2)}{0.002} = 1.256 \times 10^{-4} \, \text{Wb}
\]

\[
\Phi = \Phi_1 + \Phi_2 = 3.7699 \times 10^{-4} \, \text{Wb}
\]
Q #2 Basic Machine Design

The stator windings on the machine shown below are uniformly distributed and are modeled here as sheets of current as shown. (800 amps evenly distributed across the top, traveling out of the page; 800 amps evenly distributed across the bottom, going into the page.)

\[ l_{gap} = 1 \text{ mm (assume infinite rotor and stator permeability)} \]

a) Plot the stator-produced flux density in the gap, \( B_s \).
   Hint: Where is \( B_s \) greatest? What is \( \max B_s \)? Where is it zero?

b) At what rotor angle \( \theta_r \), will this machine generate the greatest torque?
   Note: The rotor is shown at approximately 30 degrees.

Uniform sheet of current out of page. 800 amps total current.

Uniform sheet of current into page. 800 amps total current.

\[ \mu_0 = 0.4 \times 10^{-4} \text{ wb/ATm} \]

\[ 0^\circ \qquad 90^\circ \qquad 180^\circ \qquad 270^\circ \]

\[ B_s (\text{wb/m}^2) \]

\[ 0 \qquad 90 \qquad 180 \qquad 270 \qquad 360 \]

\[ \theta (\text{deg}) \]

Q #2 Basic Machine Design

The stator windings on the machine shown below are uniformly distributed and are modeled here as sheets of current as shown. (800 amps evenly distributed across the top, traveling out of the page; 800 amps evenly distributed across the bottom, going into the page.)

\[ l_{gap} = 1 \text{ mm (assume infinite rotor and stator permeability)} \]

a) Plot the stator-produced flux density in the gap, \( B_s \).
   Hint: Where is \( B_s \) greatest? What is \( \max B_s \)? Where is it zero?

\[ \max B_s \approx 0.5 \text{ G} \quad 2\pi \approx 90, 270 \]

b) At what rotor angle \( \theta_r \), will this machine generate the greatest torque?
   Note: The rotor is shown at approximately 30 degrees.

\[ \max \text{ torque at } \theta_r = 90, 270 \text{ (when } B_s = 0) \]

Uniform sheet of current out of page. 800 amps total current.

Uniform sheet of current into page. 800 amps total current.

\[ 0^\circ \qquad 90^\circ \qquad 180^\circ \qquad 270^\circ \]

\[ B_s (\text{wb/m}^2) \]

\[ 0 \qquad 90 \qquad 180 \qquad 270 \qquad 360 \]

\[ \theta (\text{deg}) \]
Some Important Observations

• Straightforward textbook problems are not able to help students reveal and confront misconceptions
• More than half of the class did not score well for a test problem that was related to flux density and inductance

Content of the problem is not the main factor that influences group talks
Findings Reported on Discourse Development

- The semester long group talks enable noticeable shift of discourse focus, from factual to conceptual and procedural
  - *Promoting cognitive development and deep learning*
- Group dynamics influences discourse
  - *Asking more questions when developing trusts*
- The joint effort from both the instructor and students promotes discourse development
  - *Students take the ownership over their own learning*
  - *Instructors play a critical role to help students become experts*
  - *Interactions between the instructor and students shape group discussions*
Additional Findings from Detailed Discourse Analyses

- Framing problems in ways that shape group discussions has significant influences on students learning.
- Students’ verbal discourse is at the center of classroom discourse development.
- The development of classroom discourse not only demands but also relies on an active and collaborative learning environment.
- Authentic classroom discourse supports true learning and informs us on what students know and how they know it.
Summary

This study was designed to help show that our newly designed instructional model has enabled active learning through: (1) a learning community that includes both the instructor and students, and (2) classroom interactions centered on the development of classroom discourse. We conclude that

- Problematizing content combined with communicative teaching and dialogic group discussions has shown effective ways to flip lectures in engineering education;
- Quantifying discourse analysis provides much needed evidence to advance our understanding of how students learn and how we help students learn better;
- The design-based research method enables a scholarly partnership that helps advance design, practices, and research at the same time.
Acknowledgements

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References: