Introducing an Instructional Model for “Flipped Classrooms”

Part (II): How Do Group Discussions Foster Meaningful Learning?

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Purpose and Research Questions

This study is to develop an innovative instructional strategy for widespread dissemination of core courses in Electric Energy Systems Curriculum as a Model in STEM (science-technology-engineering-mathematics) education. Specifically, it is guided by the following questions:

**An Overarching Research Question:**
What impact, if any, does the new instructional model have on student learning?

- **Study I:** In what ways does the instructional model empower instructors?
  - Ways of role change for the instructor change in a non-traditional lecture hall
- **Study II:** In what ways do pedagogies enhance learning?
  - Joint efforts of a learning community co-constructing knowledge
  - Establishing classroom discourse for communicative teaching and learning
Research Questions

• How does collaborative group work, e.g. group discussions promote learning? How do we measure learning gains?

• What are the necessary instructional interventions during group problem solving?
The Four-Practice Model[1] and Active Learning[2]

I. Anticipating
- Problematizing content
- Analyze students’ learning demands

II. Monitoring
- Giving students authority
- probe students’ responses; engage in conversations with students; keep group discussions on track

III. Connecting & Contrasting
- Holding students accountable to others and norms
- Elicit questions and promote dialogic inquiries
- Connect and contrast students’ views to the discipline norms.

IV. Contextualized Lecturing
- Providing relevant resources
- Present lecture based on students’ responses
Design-Based Research Methods[3]

- An interdisciplinary approach that acknowledges the fundamentally applied nature of educational research.
- Researchers working in partnership with educators seek to refine theories of learning by designing, studying, and refining rich theory-based innovations in realistic educational environments.

http://www.designbasedresearch.org/dbr.html

• Situated in a Real Educational Context
• Mixed methods
  – Quantitative: Surveys, group discussion discourse
  – Qualitative: Classroom observations, weekly meetings with the course instructor
• Multiple Iterations in design and testing
  – Evolve from prototype problem-based learning to a Four-Practice model for instructional interventions in problem-centered learning.
• Advanced the Three Goals of Design, Research and Practice simultaneously
Setting, Data Collection, and Analysis

**Setting:**
- In the course of EE4701: Electric Drives
- 250 students (3 groups from spring 2012-2014)

**Collection**
- Students’ verbal discourse while working on problems posted by the instructor within a small group
  - Observed by the researcher
  - Audio recorded
- Online surveys at the beginning and the end of the semester
- Two focus group meetings
- Artifacts of exam papers and group problem solving worksheets

**Analysis**
- Coding schemes: the revised Taxonomy of Educational Objectives\(^4\)
- Event history approach
Rationale: why flipping classroom?

**Assumptions:**
*Students are able to learn certain types knowledge and skills without support while requiring instructional interventions for other learning tasks.*

1. Learning gap and learning potential
2. Domain knowledge presentation for hybrid instruction
   - Online video modules
   - Problematizing content to reframe domain knowledge
3. Contextual limitations
   - Communication discourse
     - Authoritative vs. dialogic
   - Problem-solving group dynamics
   - Efficacy beliefs, learning perspectives and habits

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**Zone of proximal development (Learner can do with guidance)**

**Learner cannot do unaided**

Vygotsky: Zone of Proximal Development
# Coding Scheme: (I) Knowledge Dimension

<table>
<thead>
<tr>
<th>Knowledge Type</th>
<th>Definition</th>
<th>Verbal data examples from the current study</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factual (F)</strong></td>
<td>The basic elements that students must know; to be acquainted with a discipline or solve problems in it.</td>
<td>“Isn’t P mechanical tau times omega?”</td>
</tr>
<tr>
<td><strong>Terminology, Specific details and elements</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Conceptual (C)</strong></td>
<td>The interrelationships among the basic elements within a larger structure that enables them to function together.</td>
<td>“So, what if we assume the total power we get is some torque times speed. So that torque is going to be applied by the motor no matter what.”</td>
</tr>
<tr>
<td><strong>Classifications and categories; Principles and generalization; Theories and models</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| **Procedural (P)**              | How to do something; methods of inquiry, and criteria for using skills, algorithms, techniques, and methods | “We know that 6000 minus tau minus 990 equals P loss, right?”  
“We’re trying to find mechanical power, we have to use mechanical speed.” |
| **Subject-specific skills and algorithms, techniques and methods; Criteria for determining when to use appropriate procedures** |                                                                             |                                            |
| **Metacognitive (M)**           | Knowledge of cognition in general as well as awareness and knowledge of one’s own cognition. | “I first did it using P and then added it to the answer and had it wrong.”  
“Oh! That’s where I got mixed up. It’s not omega synchronous. If you just say omega…” |
| **Strategic, Cognitive tasks including appropriate contextual and conditional knowledge; Self-knowledge** |                                                                             |                                            |
## Coding Scheme: (II) Utterance Structure/Cognitive Dimension

<table>
<thead>
<tr>
<th>Utterance structure</th>
<th>Definition</th>
<th>Cognitive process relevance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiating (IN)</td>
<td>Introducing new topics</td>
<td></td>
</tr>
<tr>
<td>Asking questions (AK)</td>
<td>Showing uncertainty about something; Seeking information and classification to increase knowledge and understanding</td>
<td>Remember, Understand</td>
</tr>
<tr>
<td>Explaining (EA)</td>
<td>Providing interpretations and reasoning</td>
<td>Understand</td>
</tr>
<tr>
<td>Exploring (EO)</td>
<td>Investigating and looking into possibilities and new ideas</td>
<td>Analyze, Evaluate, Create</td>
</tr>
<tr>
<td>Critiquing / Challenging (CR)</td>
<td>Critically reflecting on interpretations/ reasoning in which proposals may be challenged and counter-challenged.</td>
<td>Evaluate</td>
</tr>
<tr>
<td>Conscious referencing (RF)</td>
<td>Purposeful citations of established and credible information for applications and analyses</td>
<td>Apply, Analyze</td>
</tr>
<tr>
<td>Cumulative (CU)</td>
<td>Speakers build constructively and uncritically on each other’s contributions</td>
<td>Remember, Apply, Create</td>
</tr>
<tr>
<td>Key inquiry (KI)</td>
<td>Seeking key and critical information for deep understanding of content-specific knowledge and skills</td>
<td>Understand, Analyze, Evaluate, Create</td>
</tr>
</tbody>
</table>
Results (I)

(1) Utterance counts in group discussions along the knowledge type dimension
   • Worked with three different problems
   • Discussion focused more on conceptual and procedural

<table>
<thead>
<tr>
<th>Knowledge Type</th>
<th>Conceptual</th>
<th>Procedural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group O</td>
<td>69%</td>
<td>19%</td>
</tr>
<tr>
<td>Group T</td>
<td>58%</td>
<td>20%</td>
</tr>
<tr>
<td>3-Group Ave</td>
<td>33%</td>
<td>38%</td>
</tr>
</tbody>
</table>
Results (II)

(2) Dialogue counts categorized by both the knowledge type and the utterance structure.

<table>
<thead>
<tr>
<th>Utterances structure</th>
<th>CU</th>
<th>AK</th>
<th>EA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group O</td>
<td>40%</td>
<td>18.5%</td>
<td>25%</td>
</tr>
<tr>
<td>Group T</td>
<td>33%</td>
<td>22.5%</td>
<td>11%</td>
</tr>
<tr>
<td>3-Group Ave</td>
<td>34.6%</td>
<td>25%</td>
<td>24%</td>
</tr>
</tbody>
</table>

CU: Cumulative  
AK: Asking questions  
EA: Explaining
Results (III)

3. Discourse progressions during one class period.
   • Trend: Started with more talks on factual and ended with conceptual and procedural
Students’ comments on improved learning

• One (thing that) I learned better, --- that I was trying to relate equations to the physical engineering problems we were talking about. I am trying to work, --- trying to understand. I looked at equations trying to think why is this way and how it is related back to the machine. I think that I was starting thinking that way a lot---

• It is kind of similar to what XXXX said. --- I try to understand where the equation comes from and, ---I was always just to find an equation and plugged numbers in. Now, I try to see what's going on and figure out what equation and plus why. --- Biggest thing is overall problem solving.

• Not just getting an equation--- that always works. But, finding general physics behind it. --- I won't go so as far as I knew exactly where they came from as high level of skills of integrals and calculus to make it. But, I can see from the approximation. I can see how to apply it. Using these diagrams to see how to use it.

• It just emphasized lab and problem solving --- draw a picture ---. They told us so much back in physics, but just bad habits for so many years---. It's a good reminder.

• --- Starting (with) a picture, instead of --- not equations and numbers.

• --- Drawing a picture and thinking of a physical picture, before writing down the equations and getting numbers.
### Timely help

Like you got a piece of puzzle then the rest got to solve the puzzle. Like, you worked until you were exhausted and then asked for help. Not like someone just told you. --- The problem is difficult enough, and you need a hint for directions.

I do remember times when we got stuck and got hints from (the instructor). I always thought learning happened just beyond your ability. Oh, it's too easy, --- or it's too hard then you don't know what to do.

---

### Taught by example

The instructor was the example that how (he) used a lot ways--- he tried--- to teach the class. I learned by example. How he talked about problems, ---how he posted problems. Picked up a little bit of that way that how he posted the problem.

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### Contextualized Lecturing

Great, I really enjoyed it. I feel like this class added a lot of the unique value and experiences. Anyone can find a ton of great lectures and learning material online for free or low cost. I enjoyed having more interactive experiences like this one.

---Yeah (I want summary lectures), would rather have lectures after problem solving. --- Yes, you got those aha moments.
Findings

- Collaborative dialogue enables cognitive development and deep learning
  - Noticeable shift of discourse focus, from factual to conceptual and procedural
  - Learning habits Change-accepting or rejecting peers’ opinions with explanations

Manifestations of learning gains

- Group dynamics influences discourse
  - Asking more questions when developing trusts
  - Recognizing how group works are beneficial for learning

- A learning community including both the instructor and students promotes active learning
  - 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
Summary

• Pedagogies of problematizing content combined with communicative teaching and dialogic group discussions applied in the instructional model have shown effective ways to flip lectures in engineering education;

• The collaborative nature of dialogic discourse during group discussions, promoted by the model, enables knowledge co-constructing and mutual responsive learning;
  – It refines roles of the instructor highlighting both the authoritative and responsive natures in “flipped classrooms”;
  – It makes students’ understanding of knowledge and learning of knowledge audible and noticeable.
  – It requires joint efforts of a learning community including both students and the instructor.

• Challenges remain:
  – Balance activities of group discussion and contextualized lecturing
  – Balance individual need and class learning
  – Support dialogic inquiries
  – Improve epistemological beliefs of knowledge and learning
Acknowledgements

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References:
References


