Online modules increased active learning in graduate astronomy course.

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Motivation for the project

* Graduate students were not engaged, minimal classroom discussion; passive learners

* Seminal galaxy formation model could not be seamlessly integrated into in-class lessons
Project Design: 4 online modules

Pre-Module Survey:

Module 1:
- 3-2-1 reading response
- Summary essay
- Short math problem
- Video

Module 2:
- Visualization

Module 3:
- Data essay
- Discussion board

Module 4:
- Video
- Discussion board
- Synthesis essay

Post-Module Survey:

Writing-to-Learn
Multi-modal Learning
Peer Instruction, Writing-to-Learn
Peer Instruction
Evidence of student learning

Quantitative:
* Comparison of summary essays from Module 1 and exam
* Comparison of exam summary essays from Fall 2012 (lecture-style) and Fall 2013 (online modules)

Qualitative:
* Comparison of Pre- and Post-module surveys
  * student familiarity
  * student comfort level
  * student learning experience (post-)
* Visualizations and written responses
  * monitor evolution of understanding
  * identify common misconceptions
  * develop individual case studies
Evidence of student learning

**Fall 2013, module 1**
- 72% students scored 80 or above.

**Fall 2013, final exam**
- 85% students scored 80 or above.
Evidence of student learning

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Evidence of student learning

Fall 2012, without module

Fall 2013, with module

78.5%
85%
Evidence of student learning

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<table>
<thead>
<tr>
<th>Survey Question</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I feel comfortable explaining the ELS model to a member of the general public.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>75%</td>
<td>25%</td>
</tr>
<tr>
<td>I feel comfortable explaining the ELS model to another astronomer.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50%</td>
<td>50%</td>
</tr>
</tbody>
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ELS Model

Original Gas Cloud

T = 0 Gyrs
R = 100 Kpc

(a) Contracting interstellar cloud

Star Formation

Initial Rotation
T = 0 Myr
H ~ 100 Kpc
R ~ 100 Kpc

Collapse and Contraction
T = 50 Myr

Post Collapse Kinematics
T = 100 Myr
H ~ 5 Kpc
R ~ 50 Kpc

Final Galaxy
T = 10 Gyr

Note: Different outcomes correspond to different initial parameters and intergalactic exchanges.

Note: Star formation occurred prior to and during the collapse.

Note: Collapse halted my angular momentum of material.
Conclusions and Future Directions

* Preliminary results imply online modules are effective modes of content delivery and encourage active participation among graduate students.

* Will launch again, with modifications:
  * repeated*, explicit instructions and expectations
  * feedback
  * open text box for student comments in post-module survey