Classifying and Visualizing Students’ Cognitive Engagement in Course Readings

Eran Yogev, Kobi Gal, David Karger, Marc T. Facciotti and Michele Igo
ICAP framework
[Chi and Wylie 16]
ICAP framework

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Debating
Summarizing
Underlying, highlighting
Reading

Interactive
Constructive
Active
Passive

Learning
CE
Research Question

Cognitive Engagement can be a useful tool for teachers.

Approach: Combining **automatic classification** with **visualization** and **interacting with stakeholders**.

Outline

- CE in online forums,
- Classifying CE (Manual and Automatic),
- Visualization Tool and user study
Adapting CE to online Forums

[Wang et al. 16]
Example Active Reasoning

Interactive

Constructive

Active

Off Topic

What is an isoelectric point of an amino acid?
Example Interactive Reasoning (I)

Yes, I agree with you, if the interactions between the sheets change, it may cause the protein’s overall structure to change.
Nota Bene [Zyto and Karger, 2012]
The Power of Context

NB promotes

- contributions to forums
- peer feedback
- learning

An evolutionary goal of all living systems is to reproduce. Since the basic unit of life is a cell, and we know - thanks at least in part to Francisca NOG - that life begins new life - this means that there must be a process by which to create new cells from parental cells. We also know intuitively that multicellular organisms must somehow increase their number of cells during their growth by creating copies of existing cells. The process by which one cell creates one or more new cells, for both single and multi-celled organisms, requires a parental cell to divide and is called cell division.

From the standpoint of the Design Challenge framework we can stipulate that the big problem of cell division is to make a copy of a cell. If a condition for success requires that the daughter cells be viable then a number of subproblems can be defined:

1. The cell must replicate its DNA so that at least two cells have a functional copy after cell division is complete - we have discussed this process already.
2. The cell must make sufficient copies of the rest of the cellular content so that daughter cells are viable or it must find a way to ensure that the copied DNA (even without a full replica of cellular content) is viable.
3. The cell must divide the replicated cell content and DNA between at least two independently bounded compartments.
4. To ensure success, the process must be happen in an evolutionarily competitive time and be accomplished with an evolutionary selection-friendly amount of biochemical resources.

While it is not a strict requirement that this process happen in a coordinated manner, Nature has selected for systems in which all of the steps in the process happen in a highly coordinated way. This helps cells meet requirement number 4 in the list above. The coordinated process and the mechanisms of control are generally referred to as the (process). This term can be used to describe the coordinate process used by any cell that is undergoing cell division. When we observe Nature we find that it has evolved two major modes of reproduction: sexual and asexual. Within each of these modes of reproduction we find several major modes of cell division that occur frequently across all domains of life. We consider three of these modes: binary fission (used primarily by single celled bacteria and archaea), mitosis (used often by eukaryotes in processes of cell division NOT associated with sexual reproduction) and meiosis (a process of cell division tightly linked to sexual reproduction). We discuss these processes in the sections that follow.

Welcome to NB!
Use your mouse or the and keys to move from discussion to discussion.
Use your mouse or the and keys to scroll up and down the document.
Drag across any region on the pdf to create a new discussion.
Right-click on any comment to post a reply.
More help...
Wild Type is seen as the natural, normal genes of an organism, whereas a mutation is a type of change to these normal genes that can either provide a good or bad trait...

**Cell division in the bacteria and archaea**

**Bacteria and Archaea**

Like all other life forms, bacteria and archaea have one key evolutionary driver: to make more of themselves. Typically, bacterial and archaean cells grow, duplicate all major cellular constituents, like DNA, ribosomes, etc., distribute this content and then divide into two nearly identical daughter cells. This process is called binary fission and is shown mid-process in the figure below. While some bacterial species are known to use several alternative reproductive strategies including making multiple offspring or budding - and all alternative mechanisms still meet the requirements for cell division stipulated above - binary fission is the most commonly laboratory-observed mechanism for cell division the bacteria and archaea so we limit our discussion to this mechanism alone.

(Aside: Those who want to read more about alternatives to binary fission in bacteria should check this [link](#) out.)
Exam Preparation

2. The structure labeled #9 has the function of ___________ and large amounts of #9 would typically be found in cells that ___________.

A. transporting proteins produced by the ribosomes attached; secrete proteins outside of the cell
B. transporting and modifying proteins that arrive from the RER; secrete proteins outside of the cell
Manual CE Classification

1) Does the post talk about content that is related to the course? This includes both teaching content and logistics such as: lecture videos, quizzes, grades and assignments.

2) Does the post display reasoning. For example by:
   - (not only repeating or paraphrasing content)
   - Making a cause and effect relationship.
   - Comparing, or distinguishing between, two or more conditions.
   - Adding information to one of the previous posts or content around the marked text (not only repeating or paraphrasing).
   - Giving a statement and justifying it with evidence.
   - Scientific evidence, marked text, specific personal experience, etc...
   - Giving a statement (or asking a question) and giving reasons why the commenter thinks this way.
   - Drawing a conclusion based on the marked text.

3) Is this a response to a message in the thread?

4) Does the post address any of the previous discussions of the posts in the thread explicitly or implicitly?

5) Does the post introduce something new (not just paraphrasing), whether in a statement or a question, without reasoning about it. For example:
   - A new idea.
   - An answer to a question (in the marked text) but without an explanation.
   - A question or comment about content that is related to the context/document but goes beyond what's covered in it.
   - Referring to documents or resources other than the current document.

6) Is this a response to a message in the thread?

7) Does the post affirm what a previous user said? (e.g., an agreement or thank you)

8) What is the label of the previous message?

9) Does the post address any of the course subject matter.
   For example:
   -Paraphrases or repeats any course content.
   -Requests an example even without details.
   -Expresses confusion or interest or asks a question.
   -Maps any of the course content and talk about it.
   -Mapping content is any of the following: marking a text, giving references, quoting, etc.

10) Does the post shows any sign that that user is engaged with course materials without mentioning the content?
   (E.g. “I've watched the videos”, “I've read in the book”, “The teacher said”, etc.)
# Courses

<table>
<thead>
<tr>
<th>Subject</th>
<th>Course Code</th>
<th>Students</th>
<th>Annotations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physics 1</td>
<td>AP50A</td>
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<tr>
<td>Physics 2</td>
<td>AP50B</td>
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<td>Biology</td>
<td>BIS2A</td>
<td>716</td>
<td>2,212</td>
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</tbody>
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Bacteria and Archaea

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(Aside: Those who want to read more about alternatives to binary fission in bacteria should check this link out.)
1) Does the post talk about content that is related to the course?

This includes both teaching content and logistics such as: lecture videos, quizzes, grades and assignments.

- YES
- NO

Back to full tree
2) Does the comment display reasoning,
(not only repeating or paraphrasing content)
For example by:
- Proposing an explanation of a phenomenon.
- Making a cause and effect relationship.
- Comparing, or distinguishing between, two or more conditions.
- Adding information to one of the previous posts or content around the marked text (not only repeating or paraphrasing).
- Giving a statement and justifying it with evidence.
  (scientific evidence, marked text, specific personal experience, etc...).
- Giving a statement (or asking a question) and giving reasons why the commenter thinks this way.
- Drawing a conclusion based on the marked text.
3) Is this a response to a message in the thread?
C1

Back to full tree
Decision Tree Advantages

50 Annotations per hour (vs. 10-15 when using manual).
Similar inter reliability agreement (0.69 vs. 0.71 when using manual).
Used to label 6,000 messages.
Insights

Low CEs

• Definitions, questions, short comments, first posts,

\[ \text{H}_2\text{CO}_3 \overset{\text{arrows}}{\rightarrow} \text{H}_2\text{O} + \text{CO}_2 \]

shows the body’s buffering of CO₂. The arrows show the process of CO₂ is made. The purple

are antacids used to combat some way as blood buffers, are capable of absorbing pH, bringing relief to those for eating. The unique contribute to this capacity to

While the buffer system is effective, if too much base or acid -- that is particularly strong -- is introduced it will overpower the buffer and equilibrium will be thrown off. That is presumably why it is so dangerous to consume cleaning supplies or strong acids since they are so high and low, respectively, in pH
Few Occurrences of Low CE
Interactive CE

Biology

Physics 1

Physics 2
CE behavior is diverse

No variation in CE across students during the length of a course
Automatic Classification

Three families of features:

- Baseline (Bag of words)
- Context
- Student specific

Random Forest classifier (200 decision trees and 16 features).
Classification Performance

Most errors: Misclassifying Active as Constructive CE
Visualization Tool

Present CE to teachers so that

- Teacher is not overwhelmed by information.
- Bird’s eye view but also able to zoom in on individual.
- Intuitive and easy to interpret

“comments due at 11 pm the night before class, and teach 8 am the following morning.”
Student A: I’m confused by the term amino acids.
Student B: What’s the difference between amino acids and non amino acids.
Student C: I’m not sure how to answer this…

Active Targeted

Amino Acid Structure

Amino acids are the monomers that make up proteins. They consist of a central carbon atom, a carboxyl group (COOH), an amino group, a hydrogen atom, and a side chain (R group) are attached.

Possible Discussion:
Recall that one of the learning goals for this class is that you (a) be able to recognize in a molecular diagram the backbone of an amino acid and its side chain (R-group) and (b) that you be able to draw a generic amino acid. Make sure that you practice both. You should be able to recreate something like Figure 2 from memory.

Using figure 2, which of the following is true about amino acids:

a. amino acids contain polar functional groups
b. amino acids contain basic functional groups
c. amino acids contain acidic functional groups
d. amino acids contain a variable group that can be either polar or nonpolar
e. all of the above
User Study

Can the CE heat map be used as a tool:

1) that helps instructors make sense of student's interaction with the material.
2) to facilitate class design.
3) that saves instructors time and effort.
Main Findings

Instructors
- Interested in high CE
- Use CE to inform text book design
- Incentivize student learning

TAs interested in low CEs
- Provide feedback for individuals

Preferred CE heat map to default NB presentation
Summary

CE can be a useful tool for teachers.

Limitations:

• relies on hand annotated datasets.
• Need to train different models for different courses.
• difficulty in detecting paraphrasing.
• does not reason about affect.

Future work

• Does CE help students?
AI and Ed Research at BGU

Plan Recognition
Intelligent Feedback
Planning and Reasoning