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UNIVERSITY OF CALIFORNIA SAN DIEGO

# Exploring Instructional and Assessment Practices Across Faculty Types in Introductory Biology Courses

A Thesis submitted in partial satisfaction of the requirements
for the degree Master of Science

in

Biology with a Specialization in Biology Education Research

by

Ivan Man-Tsun Chim

Committee in charge:

Professor Stanley M. Lo, Chair
Professor Steven Briggs
Professor Melinda Owens

2022

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University of California San Diego

2022

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ABSTRACT OF THE THESIS

Exploring Instructional and Assessment Practices
Across Faculty Types in Introductory Biology Courses

by

Ivan Man-Tsun Chim

Master of Science in Biology with a Specialization in Biology Education Research

University of California San Diego, 2022

Professor Stanley M. Lo, Chair

Research institutions employ instructors with various faculty titles to teach undergraduate students, but it is unclear whether Tenure-track Teaching Faculty (TF) are implementing more effective learning pedagogies than their Non-Tenure track Lecturer and Tenure-track Research Faculty (RF) counterparts. To determine what types of learning pedagogies were being implemented in undergraduate biology classrooms from University of California, San Diego, we quantified their classroom learning activities with the Classroom

Observation Protocol for Undergraduate STEM (COPUS) and coded the cognitive skills needed for the corresponding exam questions with Bloom's Taxonomy. We observed that Teaching faculty engaged in significantly more Interactive activities and fewer Passive activities than Lecturers and Research Faculty. Subsequent analyses on the cognitive skills needed for exam questions revealed Teaching faculty incorporate fewer Recall questions than Research Faculty. Therefore, with significant differences in both between Research Faculty and Teaching faculty, an instructor's teaching practices may correlate with their assessment practices. Research faculty spend more time on Passive activities in the classroom, which predicts higher proportions of rote memorization questions on exams. Future work to incorporate student feedback surveys and course grades might paint a more holistic picture about the effectiveness of different teaching and assessment practices.

## INTRODUCTION

### 1.1 Research Institutions

Receiving those letters of acceptance into various colleges marks the beginning of a transformative journey for many graduating high school students. Attending college presents students the opportunity to learn and grow in many social, professional, and academic ways (Terenzini & Wright, 1987). However, the following question remains how does one choose which college to attend? Students heavily consider the quality of academics when applying to colleges, so the caliber of instructional faculty needs to be held at a high standard to deliver on the promise of a good college education (Cabrera & La Nasa, 2000). Yet, while universities establish prestige through their undergraduate education programs, an equal, if not larger focus lies on conducting cutting-edge research and pushing the boundaries of innovation (Kuh & Hu, 2001). Therefore, looking at the University of California (UC) school system may provide educators and students alike with insight into the experience of receiving a college education from an institution that engages in a high level of research.

According to the Carnegie Classification of Institutions, eight out of nine universities that make up the UC school system are currently classified as R1 research institutions (Carnegie Classification of Institutions). R1 research universities are academic institutions that heavily engage in research activities, invest at least $5 million into research, and award upwards of 20 doctoral degrees each year (Carnegie Classification of Institutions). While research faculty are required to teach a certain number of courses per year to fulfill their contractual requirements for funding, they, unsurprisingly, devote most of their time to doing research at the university (Anderson et al., 2011). Lecturers from a variety of post-secondary backgrounds are hired by these universities to teach, but are not given the opportunity to pursue tenure (American Association, 2014).

### 1.2 Tenure-Track Teaching Faculty

The UC system differs from many colleges around the country because of the development of a faculty title unique to the UC schools called Lecturer with (Potential) Security of Employment (LSOE/LPSOE), in addition to the existing research faculty and adjunct lecturers (Harlow et al., 2020). LSOEs/LPSOEs can also be referred to as teaching faculty (Harlow et al., 2020). Teaching faculty have been specifically hired to develop new courses and improve teaching pedagogies at the university, but they also conduct research and engage in community service (Harlow et al., 2020). Previously, research-track instructors were only eligible for tenure, but Teaching faculty can now pursue tenure and have the same bureaucratic rights as research faculty in the Academic Senate (UCOP, 2018). With the recent introduction of teaching faculty in the various UC campuses, the hope is that they can improve the quality of education that students are receiving.

While tenure-track teaching faculty have been hired across all academic departments at every UC campus, we have chosen to explore whether undergraduate biology teaching faculty at the University of California, San Diego (UCSD) have created classroom environments that are more conducive to increased active learning in students compared to research faculty and lecturers. In the 2020-2021 academic year, 17.4% of incoming UCSD undergraduates entered as biology majors (UCSD Institutional Research, 2022). Therefore, expanding the number of undergraduate biology instructors specifically catered to improving educational pedagogies may improve the undergraduate learning experience in the field of biology.

### 1.3 Active Learning

Previous education research has not extensively explored the role of different instructor types and its effect on classroom learning. Since Tenure-track teaching faculty are hired to promote more effective pedagogies, it would be important to identify whether such an effect exists (Harlow et al., 2020). Previous research has identified that instructors who actively engage in student-centered pedagogies instead of passive transmission of course material foster more developed critical thinking skills in students (Prosser et al., 1994). However, simply implementing active learning activities in the classroom may not be enough to help students further their reasoning skills. Biology instructors incorporate various activities that go beyond the rote memorization of facts, but if they do not understand how to further engage and develop students' thinking, there is no clear benefit of active learning (Andrews et al., 2011). One way to successfully integrate active learning pedagogies may be to have instructors reevaluate their roles as authorities and guides, and instead be promoters of student-centered discussion (Kranzfelder et al., 2020).

### 1.4 Classroom Observation Protocol for Undergraduate STEM

When examining how undergraduate biology instructors create their classroom environments, we can assess their teaching and assessment practices. Instructor teaching practices can be identified using COPUS (Chi, 2009). COPUS stands for Classroom Observation Protocol in Undergraduate STEM, and involves coding audio recordings of classroom activities, which includes both student and instructor activities (Smith et al., 2013). These activities can then be classified into six categories: Passive, Active, Constructive, Interactive, Motivational, and Other (Chi, 2009). Since active learning is touted to promote student learning, seeing if any other styles of classroom learning lead to higher student engagement could further improve classroom practices (Ruiz-Primo et al., 2011). Moreover, presenting instructors with a detailed breakdown of their time usage during class times can allow them to evaluate which areas of instruction can be better utilized (Smith et al., 2013). However, using COPUS data alone to qualify the effectiveness of different instructors' classroom practices may not reveal the entire picture (McConnell et al., 2021).

**1.5 Bloom's Taxonomy**

After identifying the classroom learning activities, we can investigate how instructors write their exams by coding each assessment item with a cognitive and knowledge code with the help of Bloom's Taxonomy. Bloom's Taxonomy provides coders with six cognitive codes—Recall, Understand, Apply, Analyze, Evaluate, Create—and four knowledge codes—Factual, Conceptual, Procedural, Metacognitive—for classification (Anderson et al., 2001). Those who have used Bloom's Taxonomy to analyze exam questions have generally acknowledged that the six cognitive codes can be divided into lower and higher demanding cognitive functions (Anderson et al., 2001). Questions that fall under Recall and Understand require less cognitive demand than questions categorized as Apply, Analyze, Evaluate, and Create (Anderson et al., 2001). Even if the goal of all biology instructors is to foster greater critical thinking in their students, writing exams that largely comprise of questions with lower Bloom's codes leads students to prioritize rote memorization and basic fact recall over higher cognitive skills like analysis and evaluation (Momsen et al., 2017). Instructors may be unintentionally writing exams that reinforce students' lower-level cognitive skills more often than desired (Crowe et al., 2008). In the pursuit of quality higher education, we are interested in whether different instructor types tend to favor lower or higher cognitive questions on exams. When students have more exposure to questions with higher levels of Bloom's codes, it is possible that they understand course content in a more complex manner and can better apply the knowledge on exams.

### 1.6 Hypothesis

COPUS may help instructors identify potential areas of improvement in their classroom practices and applying Bloom's Taxonomy to exams may reveal gaps between instructor learning objectives and exam questions. Therefore, the questions I aim to address in the thesis are 1) Does the faculty title of undergraduate biology faculty correlate with classroom teaching practices (as defined by COPUS), and 2) Does the faculty title of undergraduate biology faculty correlate with assessment practices (as defined by Bloom's Taxonomy)?

## METHODS

### *Data Collection*

Collecting COPUS and Bloom's data began with compiling a list of every instructor who taught one of four introductory biology courses at a large public university. Each instructor was emailed by the research group asking for permission to conduct live, in-person COPUS coding in the classroom as well as to collect assessment items, like midterms or quizzes, from previous quarters. Not every instructor who consented to the data collection allowed both COPUS and Bloom's data to be collected. Instructors could consent to only providing one or the other.

To collect COPUS data, the coders first familiarized themselves with codes in each of the six PACIMO categories. Then, coders were assigned to attend the lectures of one of the four designated introductory biology courses. For every two-minute interval of classroom activity, coders would record what activities the instructors and students were engaged in. It was possible for instructors and students to be engaged in multiple activities with different PACIMO categories within the two-minute interval. PACIMO is a re-organization of the original COPUS framework. In addition to the existing Passive, Active, Constructive, and Interactive codes, Motivational and Other categories were added. Coders recorded all activities until the lecture ended, regardless of the allocated 50- or 80-minute lecture window. The coders attended lectures from two quarters of the academic calendar. Also, instructor and student activities were separately coded, so each population had different sets of activities fall under the six PACIMO categories. Interrater reliability of coding was confirmed by reaching a high Jaccard index.

Before coding assessment items with Bloom's Taxonomy, three undergraduate coders read literature about the qualities and definitions of the various cognitive and knowledge codes attributed to the taxonomy. There was also a guidebook created by a post-doctoral student that was provided to the undergraduate coders for further clarification about the various dimensions. Every assessment item was coded with a cognitive dimension (denoted by numbers 1-6) and knowledge dimension (denoted by letters A-D). Each coder started off coding the same set of 100 assessment items to determine interrater reliability. When there were disagreements with any assigned codes, the coders discussed their reasoning with each other until a consensus code was reached. After reaching a Cohen's Kappa of 0.7, the three coders were assigned different assessment questions to independently code the remaining assessment items. While assessment items appeared as different question types, like multiple choice to free response questions, the coders still applied Bloom's Taxonomy codes to the questions.

***Data Analysis***

After the COPUS data collection occurred, codes were aggregated into their respective PACIMO categories and separated by the three instructor types. Similarly, Bloom's codes were aggregated into two tables, one for cognitive codes and one for knowledge codes, before being separated by instructor type. A Fisher Exact Test for Counts was performed on each set of data to determine whether there were significant associations between the two categorical variables: instructor type and COPUS activity code or instructor type and Bloom's Taxonomy code. Then, a Pearson's Chi-squared test was performed to determine whether there were significant differences in the various COPUS or Bloom's codes across the three instructor types. A Bonferroni post-hoc test was applied to the chi-squared test to reduce the effect of Type I errors. We conducted a correspondence analysis on the COPUS data to test how instructor type and COPUS codes were associated with each other. Following the correspondence analysis, hierarchical clustering allowed us to revisualize the data into similar clusters. Categories closer in distance to each other had stronger associations with each other. A correspondence analysis and hierarchical clustering were also performed using the Bloom's Taxonomy codes as well. All data analysis was performed using R.

## RESULTS

### Instructor Teaching Practices

We first hypothesized that instructors with differing faculty titles would demonstrate differing distributions of classroom activities. Analysis of the PACIMO code distributions for each instructor type, revealed relationships between different instructor types. An initial Fisher's Exact Test for Count Data of the three instructor types and six PACIMO codes revealed a simulated $p<0.0005$. Therefore, the three instructor types did have significant associations with PACIMO codes. A subsequent Pearson's Chi-squared test supported the claim that all three instructor types engaged in significantly different proportions of PACIMO classroom behaviors with $p<2.2e-16$. We also performed Bonferroni post-hoc tests on the chi-squared values to parse out any specific significant differences in PACIMO codes between each pair of instructor types: 1) Lecturer versus Research Faculty, 2) Lecturer vs Teaching Faculty, and 3) Research Professors versus Teaching Faculty.

Among the three groups of instructors, teaching faculty engaged in significantly more Interactive activities (13.8%) compared to their Lecturer (3.9%) and Research faculty (1.6%) counterparts (Fig. 1A), confirmed by Bonferroni corrections with a residual of 12.331 and $p<0.00001$. Teaching faculty (31.9%) also appeared to spend proportionately less time on Passive activities compared to Lecturers (40.9%) and Research faculty (49.4%) (Fig. 1A), confirmed by Bonferroni corrections with a residual of -8.193 and $p<0.00001$. Individually analyzing the other four learning types—Active, Constructive, Motivational, Other—revealed no statistical differences across the three instructor types.

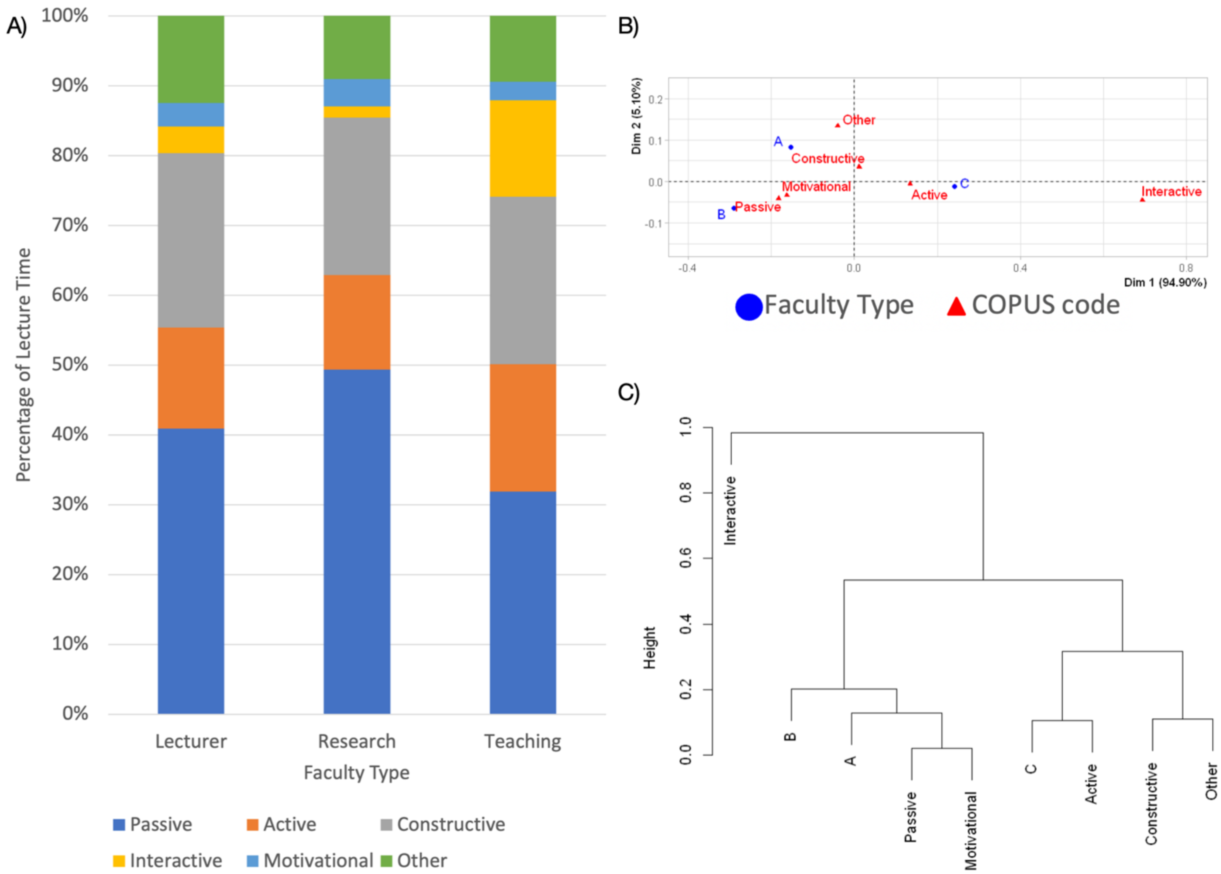



**Figure 1. Teaching faculty perform more Interactive activities and fewer Passive activities than Lecturers and Research faculty.** A) Average distribution of Classroom Observation Protocol for Undergraduate STEM (COPUS) PACIMO codes (Passive, Active, Constructive, Interactive, Motivational, Other) for instructor classroom activities when Lecturers (n=3), Research Faculty (n=5), and Teaching Faculty (n=4) taught their respective classes. Codes obtained from live observational coding of in-person lectures. B) Scatterplot of correspondence analysis, measuring the variance in data across COPUS code (Dimension 1) and faculty type (Dimension 2). Point A represents Lecturers. Point B represents Research Faculty. Point C represents Teaching Faculty. C) Hierarchical clustering of correspondence analysis grouped COPUS code nodes and faculty type nodes into similar clusters.

When conducting a correspondence analysis (Fig. 1B), Dimension 1, or the instructor types, accounted for 94.9% of the variance, supporting the idea that instructor type differences are important. With Interactive COPUS codes plotted the furthest from the origin (Fig. 1B), Interactive codes were likely the most differentiable code among the three instructor types. Finally, the associated hierarchical clustering (Fig. 1C) revealed two distinct clusters. Lecturers and Research faculty were most associated with Passive activities, whereas Teaching faculty were most associated with Active activities. Despite being significantly different in earlier statistical analyses, Interactive activities were the least related to any of the instructor types (Fig. 1C).

In addition to identifying what instructors were doing in class, we thought it was also important to understand what types of classroom activities students were engaged in. Both the Fisher's Exact Test ($p<0.0005$) and Pearson's chi-squared test ($p<2.2e-16$) revealed there were significant differences in what activities students were engaged in classrooms led by different instructor types.

Students in teaching faculty-led lectures spent significantly more time in class participating in Constructive activities (14.8%) than students in Lecturer-led (9.5%) and Research Faculty-led (3.1%) lectures (Fig. 2A), as supported by a Bonferroni correction with a residual of 7.704 and $p<0.000001$. Moreover, students in teaching faculty-led lectures also spent less time engaging in Passive activities (51.2%) than students in Lecturer-led (56.3%) and Research faculty-led (69.5%) lectures (Fig. 2A), as supported by a Bonferroni correction with a residual of -6.454 and $p<0.000001$.

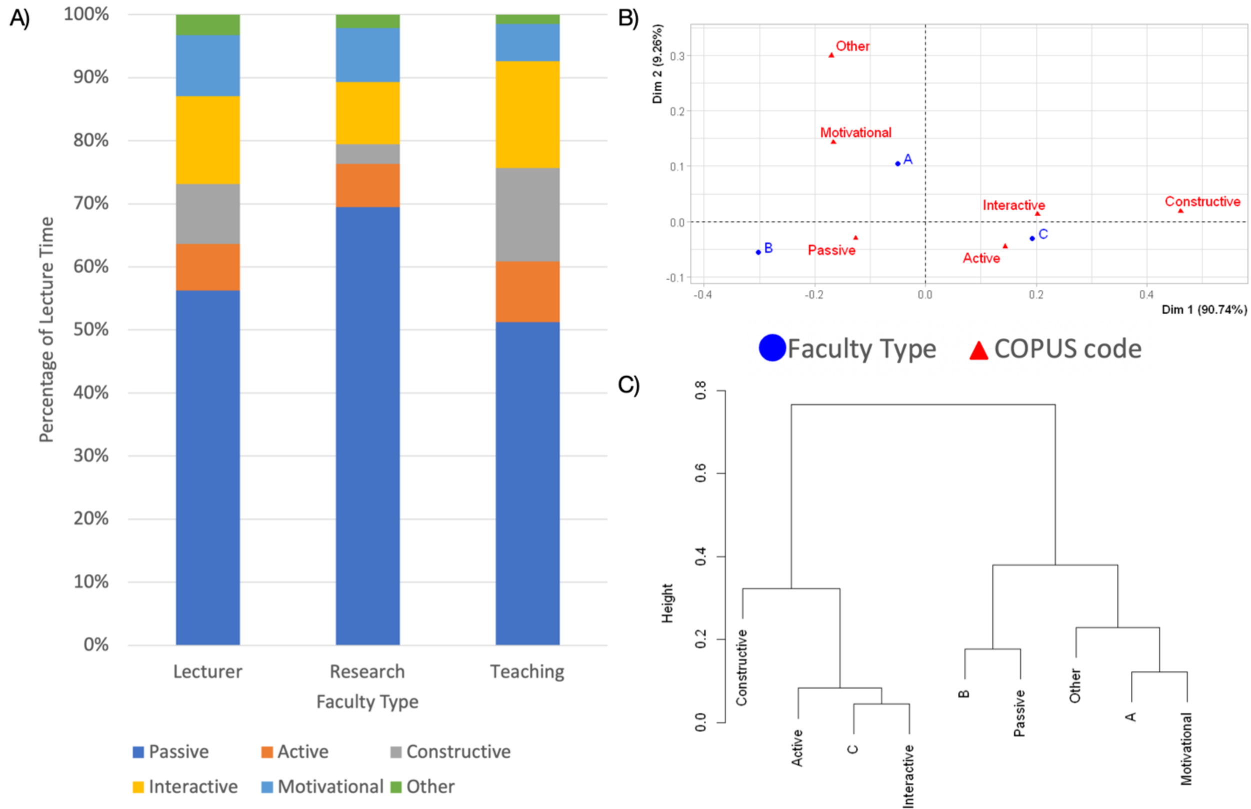



**Figure 2. Students spend more class time performing Constructive Activities and less time on Passive Activities in classrooms taught by Teaching Faculty compared to Lecturers and Research Faculty.** A) Average distribution of Classroom Observation Protocol for Undergraduate STEM (COPUS) PACIMO codes (Passive, Active, Constructive, Interactive, Motivational, Other) for student classroom activities when Lecturers (n=3), Research Faculty (n=5), and Teaching Faculty (n=4) taught their respective classes. Codes obtained from live observational coding of in-person lectures. B) Scatterplot of correspondence analysis, measuring the variance in data across COPUS code (Dimension 1) and faculty type (Dimension 2). Point A represents Lecturers. Point B represents Research Faculty. Point C represents Teaching Faculty. C) Hierarchical clustering of correspondence analysis grouped COPUS code nodes and faculty type nodes into similar clusters.

The associated correspondence analysis (Fig. 2B) also revealed that the Constructive COPUS code was most discriminatory when comparing the three instructor types. Like the correspondence analysis of instructor COPUS codes (Fig. 1B), the correspondence analysis of student COPUS codes (Fig. 2B) orients teaching faculty and research faculty as being the most dissimilar to each other and Lecturers in between the two groups. When examining the hierarchical clustering (Fig. 2C), we noticed two clusters separating teaching faculty from

Lecturers and Research faculty. Again, we saw teaching faculty most associated with Interactive activities and Research faculty most associated with Passive activities (Fig. 2C). However, Lecturers had the closest association with Motivational activities (Fig. 2C).

**Instructor Assessment Practices**

As we moved onto exploring whether instructor type had any influence on assessment practices, we hypothesized that instructors with different instructor titles would create assessment questions with different distributions of cognitive actions. Beginning data analysis with a Fisher's Exact Test ($p<0.0005$) and Pearson's Chi-squared test ($p<9.92e-10$) supported the idea that there were significant differences in the frequency of cognitive skills being highlighted on exams.

Regardless of instructor type, a large portion of each group's assessment questions were written as Recall questions (Fig. 3A). However, teaching faculty included significantly fewer Recall questions (38.8%) on their assessments compared to Lecturers (49.5%) and Research faculty (60.6%) (Fig. 3A), as supported by a Bonferroni correction with a residual of -5.569 and $p<0.000001$. Teaching faculty also included more significantly more Evaluate questions (4.5%) in assessments compared to assessments written by Lecturers (0.1%) and Research faculty (0.04%) (Fig. 3A), supported by a Bonferroni correction with a residual of 4.696 and $p<0.00005$.

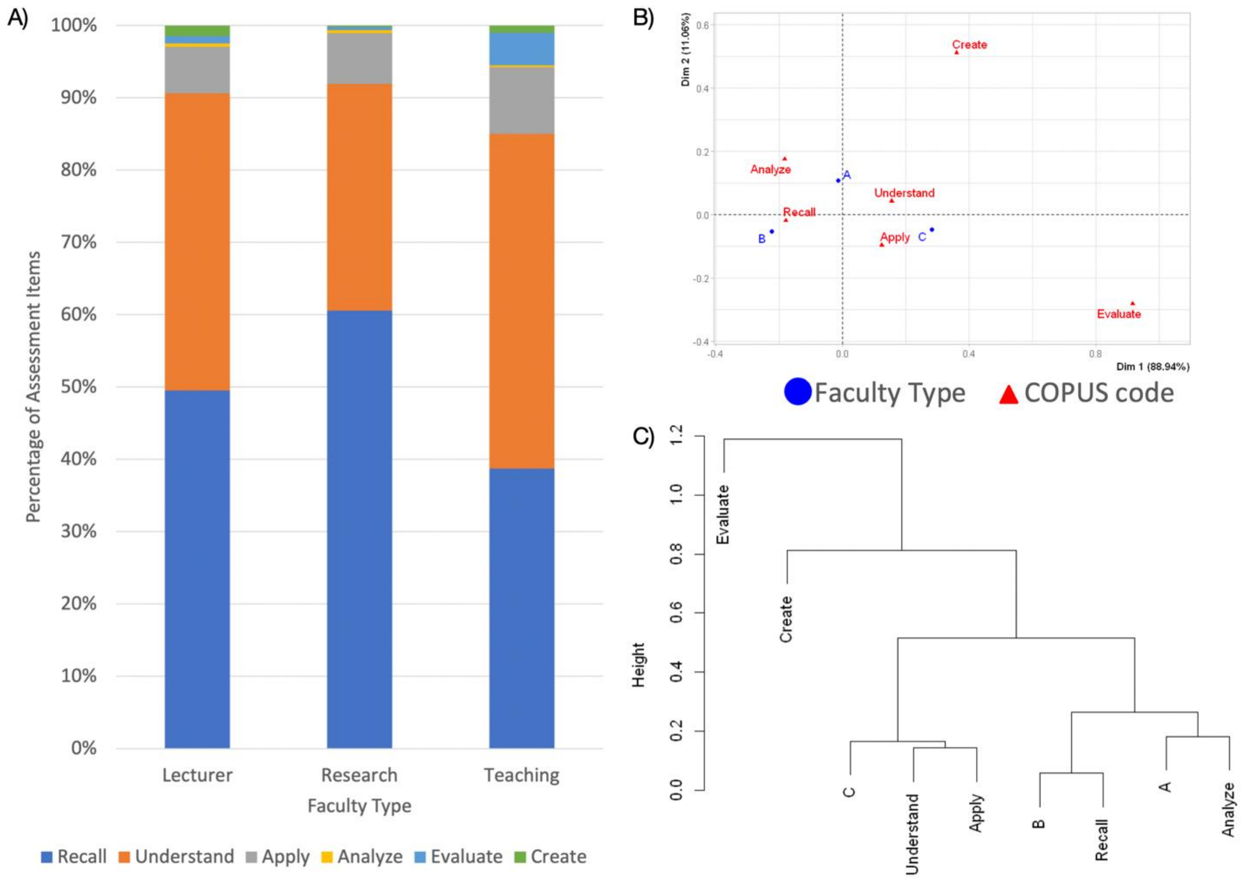
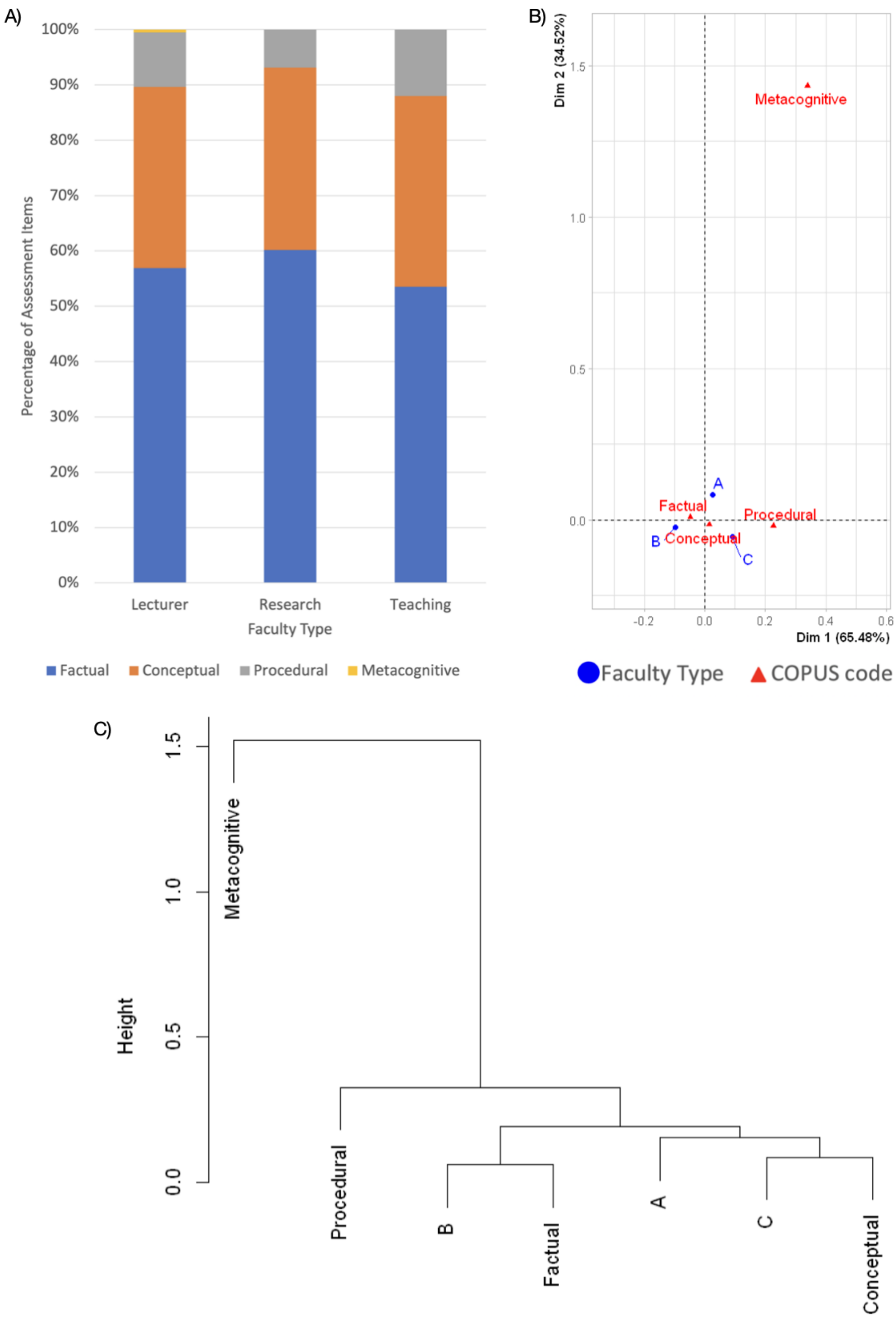



**Figure 3. Teaching Faculty write fewer Recall questions and more Evaluate questions than Lecturers and Research Faculty.** A) Average distribution of the Bloom's Taxonomy cognition codes from assessment items assigned by Lecturers (n=3), Research Faculty (n=5), and Teaching Faculty (n=4) to students. B) Scatterplot of correspondence analysis, measuring the variance in data across Bloom's Taxonomy cognition code (Dimension 1) and faculty type (Dimension 2). Point A represents Lecturers. Point B represents Research Faculty. Point C represents Teaching Faculty. C) Hierarchical clustering of correspondence analysis grouped Bloom's Taxonomy cognition code nodes and faculty type nodes into similar clusters.

When examining the correspondence analysis (Fig. 3B), Evaluate questions also appear to be the most differentiable across the three instructor types. However, Evaluate questions appear to be the least associative cognitive code to any of the three instructor types (Fig. 3C). The hierarchical clustering reveals that teaching faculty were instead closely associated with Understand and Apply questions, and Research faculty were closely associated with Recall questions (Fig. 3C).

After analyzing what cognitive skills instructors emphasized on exams, we also looked at what types of knowledge were being emphasized on exams as well. Unlike with cognitive skill analysis, both the Fisher's Exact Test ($p<0.052$) and Pearson's chi-squared test ($p<0.050$) revealed there were not significant differences in what types of knowledge were represented on assessments written by any instructor type. There were no significant differences in any of the four knowledge types—Factual, Conceptual, Procedural, Metacognitive—across the three instructor types as there were similar proportions of each knowledge type (Fig. 4A).

**Figure 4. All instructor types incorporate similar frequencies of knowledge types in assessment items.** A) Average distribution of the Bloom's Taxonomy knowledge codes from assessment items assigned by Lecturers (n=3), Research Faculty (n=5), and Teaching Faculty (n=4) to students. B) Scatterplot of correspondence analysis, measuring the variance in data across Bloom's Taxonomy knowledge code (Dimension 1) and faculty type (Dimension 2). Point A represents Lecturers. Point B represents Research Faculty. Point C represents Teaching Faculty. C) Hierarchical clustering of correspondence analysis grouped Bloom's Taxonomy knowledge code nodes and faculty type nodes into similar clusters.


A)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Assessment Items
Lecturer
Research
Teaching
Faculty Type
Factual
Conceptual
Procedural
Metacognitive
B)
Dim 2 (34.52%)
1.5
1.0
0.5
0.0
-0.2
0.0
0.2
0.4
0.6
Dim 1 (65.48%)
Metacognitive
A
Factual
Procedural
B
Conceptual
C
Faculty Type
COPUS code
C)
Height
1.5
1.0
0.5
0.0
Metacognitive
Procedural
B
Factual
A
C
Conceptual

## DISCUSSION

Statistical analysis revealed that Research faculty partake in more Passive activities and fewer Interactive activities compared to their Lecturer and Teaching faculty counterparts. Additional analysis of the four other activity codes (Active, Constructive, Motivational, Other) did not reveal significant differences between the three instructor groups. Therefore, focusing on decreasing Passive activities may reveal possible areas of improvement in the teaching pedagogies of Research faculty. Passive activities in the classroom implies that students have fewer opportunities to ask or answer questions about the material and instead only listen to the instructor lecturing (Chi, 2009; Smith, 2013). As a result, this may lead students to prioritize cognitive skills like rote memorization and basic fact recall, instead of higher-level cognitive skills like analysis or evaluation (Crowe, 2008).

There were also significantly fewer Interactive activities in Research faculty-led classrooms, so incorporating more Interactive activities may also promote more effective student learning. Modeling course design after Teaching faculty, who partake in significantly more Interactive activities in lectures, may guide other instructors towards engaging students in more effective learning. Interactive activities include student-peer discussions and group-work, so fostering stronger interpersonal communication could also promote higher student engagement with material (Chi, 2009). Small group discussions would allow each student to think about the material before sharing their understanding of the material with their peers. As a result, students could gain clarity or a new understanding about the material from their peers that would not have happened if not for the discussion.

Traditionally, Research faculty appear to prioritize lecturing to students, instead of engaging in classroom discussions about the material (Robert & Carlson, 2017). Similarly, our study showed that Research faculty spent most of the class time on passive activities, such as lecturing from slideshows or writing content on the board. Research faculty may see teaching students as a secondary obligation to their main objective of conducting research, especially for Research faculty who have not obtained tenure (Tian & Lu, 2017). Therefore, they may tend to transmit information to students without making sure students have understood the necessary lecture content. With research as their main priority, these instructors may not actively spend time improving their teaching pedagogies. Alternatively, research professors may not collaborate as much with other instructors and discuss what teaching pedagogies seem to be working for their students.

**Limitations**

In this project, we are possibly limited by the fact that our current study did not investigate how instructors prepare for instruction. Preliminary preparation could include how instructors designed classroom activities, how they wrote exams, and how they decided what information was relevant for the course. As such, we currently do not know if there was prior discourse between instructors when designing their courses for students. Further examining these faculty relationships may lead to further discussion about the role of professional development programs or faculty peer support groups in promoting effective classroom teaching. Lastly, data collected from co-taught lectures was excluded from the final data analysis. Identification of which instructor performed what activities or which instructor wrote which assessment items was not noted at the time of data collection. Including these data with a specific faculty type could have altered the data analysis because the co-teaching instructors held different faculty titles.

## Future Directions

To further investigate the effect of classroom teaching and assessment practices on student learning, we propose to incorporate anonymous student feedback surveys in future studies. These surveys would ask about students' perceived levels of class engagement and confidence in understanding the course material. Student feedback could inform future course design when students point out what classroom practices were helpful or not. Providing students with an opportunity to honestly communicate their thoughts and feelings about the course could give instructors insight about their own teaching practices.

In combination with student feedback surveys, student grade data may also provide greater insight into the outcomes of certain educational pedagogies. Correlative alignment between positive student feedback surveys and high academic performance could indicate that certain instructors are creating more effective learning environments for their students. As such, further analyzing the COPUS profiles and Bloom's profiles of individual instructors could reveal what specific classroom activities or assessment practices are driving students' learning and academic performance. Grouping instructors based on their faculty titles may be erasing these specific differences, so further investigation into individual instructors is close on the horizon.

Instructors and students are both responsible for creating an environment conducive for effective learning and engagement. Therefore, it is important to look at improving classroom learning from both the instructor and student sides.

APPENDIX

**Table 1. Instructor COPUS Codes**

| COPUS Code | Associated Activities |
|---|---|
| Passive | Demonstrations, Playing videos, Lecturing, Writing |
| Active | Answering questions, Follow-up questions, Recommending resources |
| Constructive | Making Big Picture Connections, Asking Clicker Questions, Linking concepts, Posing a question, Providing relevant examples |
| Interactive | One-on-one interactions, Guiding/Moving conversation, Engaging Teaching Assistants |
| Motivational | Connecting to life, Discouraging students, Encouraging students, General student development |
| Other | Administrative tasks, Waiting |

**Table 2. Student COPUS Codes**

| COPUS Code | Associated Activities |
|---|---|
| Passive | Listening to instructor |
| Active | Answering questions, Presenting, Asking questions |
| Constructive | Individual work, Predicting, Assessments |
| Interactive | Discussing Clicker questions, Other group work, Whole class discussion, Worksheet group work |
| Motivational | Disruptive behavior, Students helping Students |
| Other | Waiting |

**Table 3. Cognitive Processes in Bloom's Taxonomy**

| Categories and Cognitive Processes | Definition |
|---|---|
| **1. Remembering - Retrieving relevant information** | |
| 1.1 Recognizing, Identifying | Making direct connections b/w knowledge and question |
| 1.2 Recalling, Retrieving | Finding direct connections b/w knowledge and question |
| **2. Understanding - Constructing meaning from information** | |
| 2.1 Interpreting, Translating | Changing forms of expression |
| 2.2 Exemplifying, Illustrating | Finding specific examples of a concept |
| 2.3 Classifying, Categorizing | Ordering items into categories |
| 2.4 Summarizing, Generalizing | Finding the main idea |
| 2.5 Inferring, Predicting | Drawing logical conclusions |
| 2.6 Comparing, Contrasting | Identifying similarities and differences |
| 2.7 Explaining, Constructing models | Finding a cause-and-effect relationship |
| **3. Applying - Carrying out a procedure** | |
| 3.1 Executing, Carrying out | Applying a procedure to a **familiar** task |
| 3.2 Implementing, Using | Applying a procedure to an **unfamiliar** task |
| **4. Analyzing - Relating parts of material to bigger picture** | |
| 4.1 Differentiating, Distinguishing | Selecting relevant from irrelevant parts of presented material |
| 4.2 Organizing, Structuring | Determining how each part fits into the structure |
| 4.3 Attributing, Deconstructing | Finding points of view, bias, values, intent |

**Table 3. Cognitive Processes in Bloom's Taxonomy (Cont)**

| | |
|---|---|
| **5. Evaluating - Making judgments based on standards** | |
| 5.1 Checking, Detecting | Looking for **internal** consistency (within a process/product) |
| 5.2 Critiquing, Judging | Looking for **external** consistency (between processes) |
| **6. Creating - Organizing information into a coherent structure** | |
| 6.1 Generating, Hypothesizing | Creating possible, relevant hypotheses |
| 6.2 Planning, Designing | Creating a procedure to accomplish a task |
| 6.3 Producing, Constructing | Creating a product |

**Table 4. Knowledge Categories in Bloom's Taxonomy**

| Categories and Cognitive Processes | Definitions |
| --- | --- |
| **A. Factual Knowledge** | |
| Aa. Terminology | Technical vocabulary, nonverbal symbols |
| Ab. Specific details and Elements | Events, locations, people, dates, sources of information, criteria lists, names of principles/laws **(Not required to understand the large context)** |
| **B. Conceptual Knowledge** | |
| Ba. Classifications and Categories | Specific categories, classes, divisions, and arrangements **(Understand the reason for classifications)** |
| Bb. Principles and Generalizations | Processes, laws **(Combines specific facts into generalizations without need to interrelate them)** |
| Bc. Theories, Models, and Structures | Different paradigms, epistemologies, theories, and models used to describe, understand, explain, and predict phenomena |
| **C. Procedural Knowledge** | |
| Ca. Subject-specific skills and algorithms | Series or sequence of steps, collectively known as procedure **(What)** |
| Cb. Subject-specific techniques and methods | Knowledge that is largely the result of consensus, agreement, or disciplinary norms. Knowledge of techniques that do not lead to a single predetermined answer. |
| Cc. Criteria for determining appropriate procedures | Knowledge of conditions in which procedures are used |
| **D. Metacognitive Knowledge** | |
| Da. Strategies | Strategies for learning, thinking, and problem solving |
| Db. Cognitive Tasks: Contextual and Conditional | When best to use metacognitive knowledge/metacognitive tools. |
| Dc. Self-knowledge | One's strengths and weaknesses related to cognition and learning. |

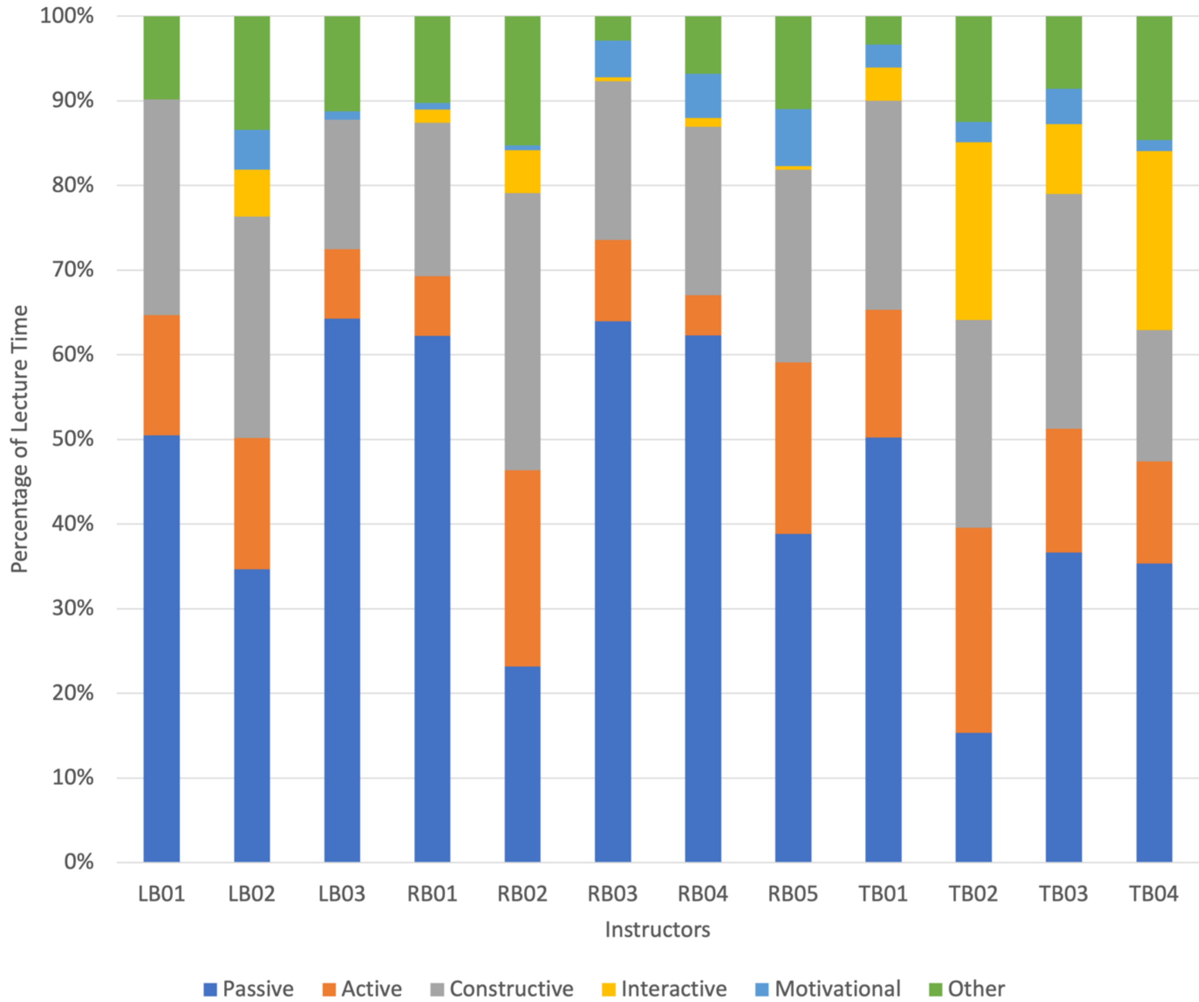



**Figure 5. Individual instructor activity COPUS profiles.** Average distribution of Classroom Observation Protocol for Undergraduate STEM (COPUS) PACIMO codes (Passive, Active, Constructive, Interactive, Motivational, Other) for instructor classroom activities when individual Lecturers (n=3), Research Faculty (n=5), and Teaching Faculty (n=4) taught their respective classes. Codes obtained from live observational coding of in-person lectures.

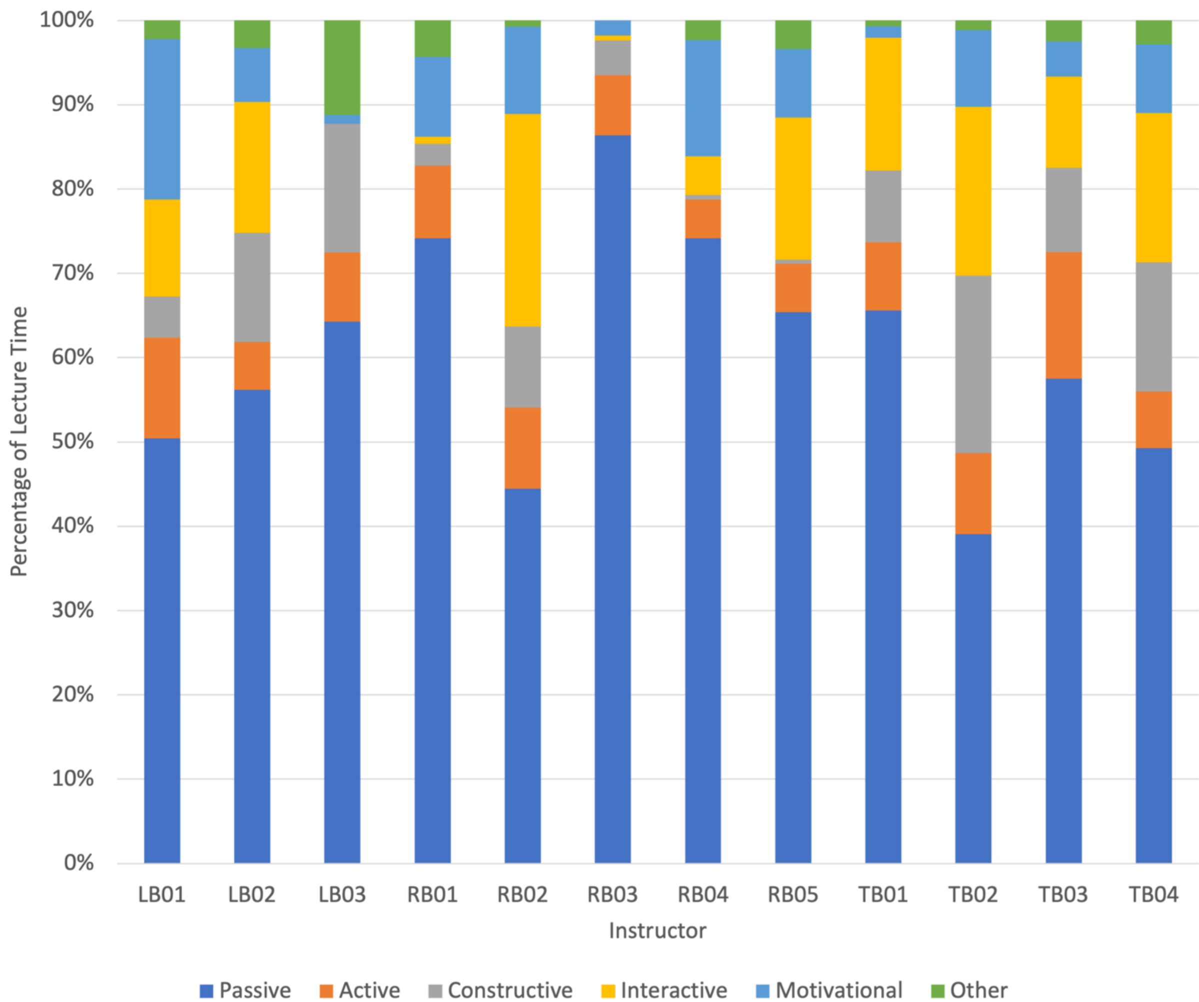



**Figure 6. Individual student activity COPUS profiles.** Average distribution of Classroom Observation Protocol for Undergraduate STEM (COPUS) PACIMO codes (Passive, Active, Constructive, Interactive, Motivational, Other) for student classroom activities when individual Lecturers (n=3), Research Faculty (n=5), and Teaching Faculty (n=4) taught their respective classes. Codes obtained from live observational coding of in-person lectures.

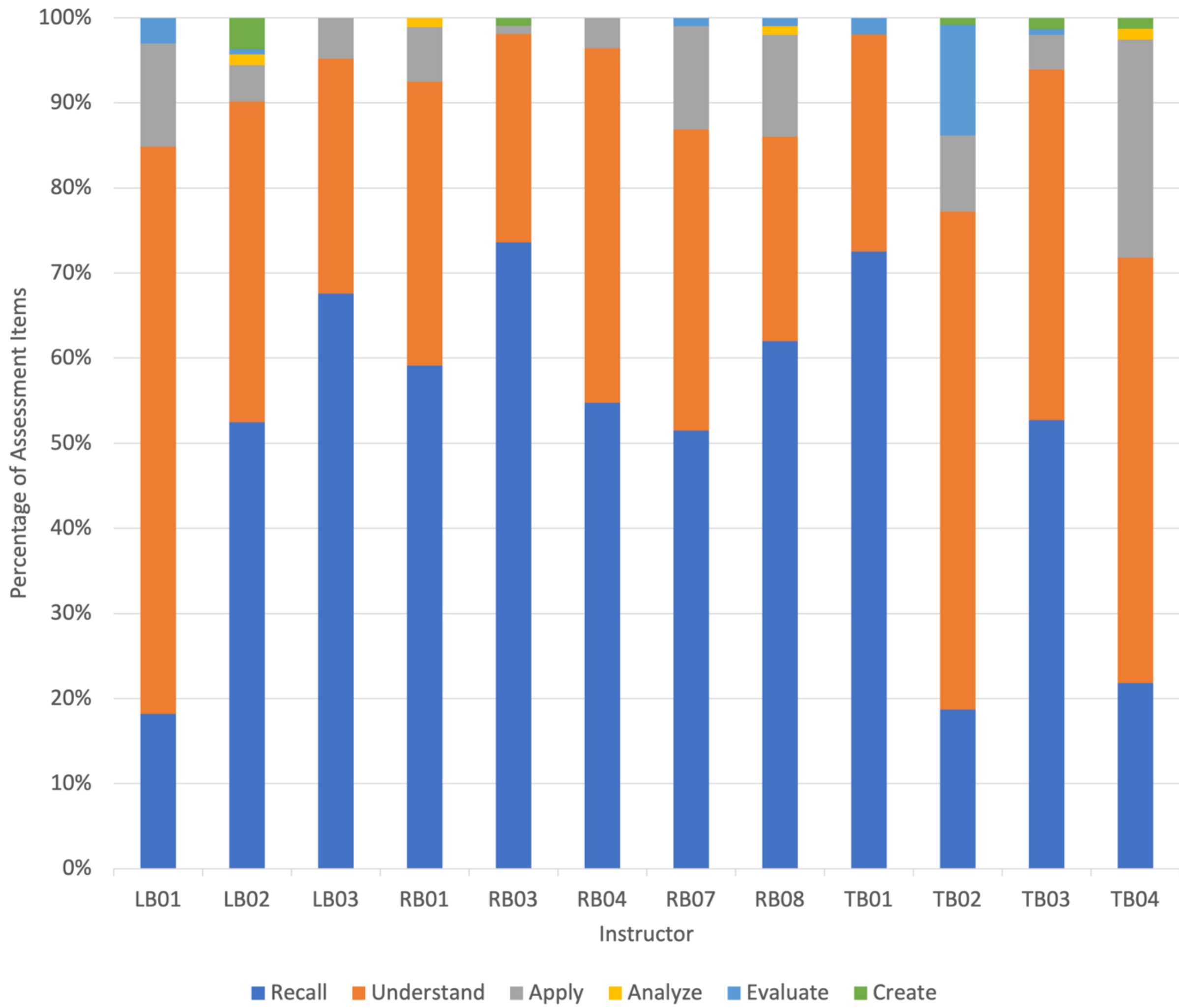



**Figure 7. Individual instructor Bloom's cognition profiles.** Average distribution of the Bloom's Taxonomy cognition codes from assessment items assigned by individual Lecturers (n=3), Research Faculty (n=5), and Teaching Faculty (n=4) to students.

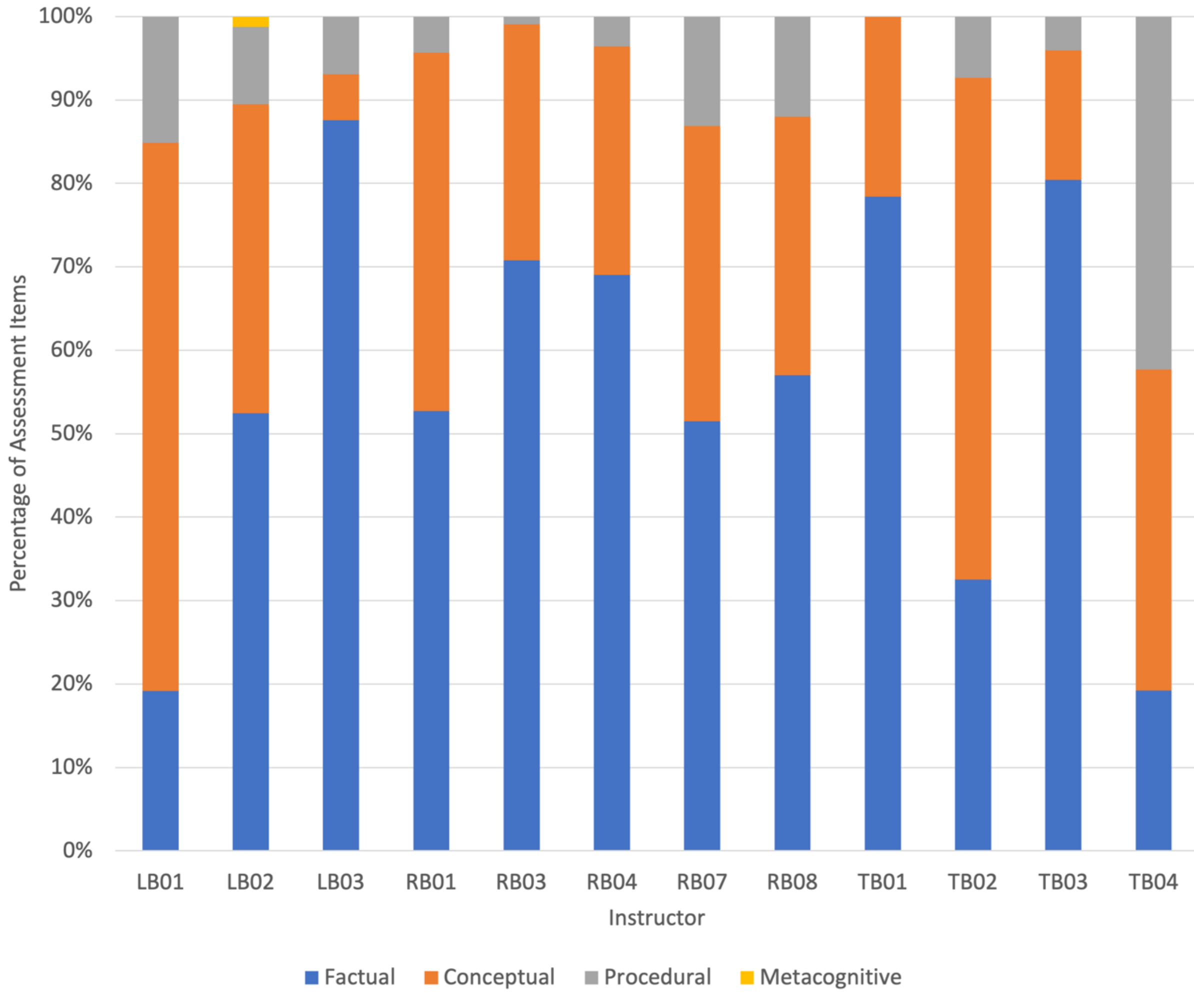



**Figure 8. Individual instructor Bloom's knowledge profiles.** Average distribution of the Bloom's Taxonomy cognition codes from assessment items assigned by individual Lecturers (n=3), Research Faculty (n=5), and Teaching Faculty (n=4) to students.

REFERENCES

American Association of University Professors. (2014). Contingent appointments and the academic profession.

Anderson, L.W., Krathwohl, D.R., Bloom B.S. (2001). A Taxonomy for Learning, Teaching, and Assessing a Revision of Bloom's Taxonomy of Educational Objectives, New York, NY: Longman.

Anderson, W.A., Banerjee, U., Drennan, C.L., Elgin S.C.R., Epstein, I.R., Handelsman, J., Hatfull, G.F., Losick, R., O'Dowd, D.K., Olivera, B.M., Strobel, S.A., Walker, G.C., Warner, I.M. (2011). Changing the Culture of Science Education at Research Universities. Science, 331(6014), 152-153.

Andrews, T.M., Leonard, M.J., Colgrove, C.A. & Kalinowski, S.T. (2011). Active Learning Not Associated with Student Learning in a Random Sample of College Biology Courses. CBE Life Sciences Education, 10(4), 394–405.

Cabrera, A.F., La Nasa, S.M. (2000). Understanding the College-Choice Process. New Directions for Institutional Research, 2000(107), 5-22.

Chi, M. T. H. (2009). Active-Constructive-Interactive: A Conceptual Framework for Differentiating Learning Activities. Topics in Cognitive Science, 1(1), 73–105.

Crowe, A., Dirks, C., & Wenderoth, M. P. (2008). Biology in bloom: implementing Bloom's taxonomy to enhance student learning in biology. CBE—Life Sciences Education, 7(4), 368-381.

Harlow, A., Lo, S. M., Saichaie, K., Sato, B. K. (2020). Characterizing the University of California's tenure-track teaching position from the faculty and administrator perspectives. PLoS ONE, 15(1), 1-14.

Kranzfelder, P., Bankers-Fulbright, J. L., García-Ojeda, M. E., Melloy, M., Mohammed, S. & Warfa, A.-R. M. (2020). Undergraduate Biology Instructors Still Use Mostly Teacher-Centered Discourse Even When Teaching with Active Learning Strategies. BioScience, 70(10), 901–913.

Kuh, G.D., Hu, S. (2001) Learning Productivity at Research Universities. The Journal of Higher Education, 72(1), 1-28.

McConnell, M., Boyer, J., Montplaiser, L. M., Arneson, J. B., Harding, R. L.S., Farlow, B., Offerdahl, E. G. (2021). Interpret with Caution: COPUS Instructional Styles May Not Differ in Terms of Practices That Support Student Learning. CBE—Life Sciences Education, 20(2), 1-9.

Momsen, J. L., Long, T. M., Wyse, S. A., & Ebert-May, D. (2010). Just the facts? Introductory undergraduate biology courses focus on low-level cognitive skills. CBE—Life Sciences Education, 9(4), 435-440.

Prosser, M., Trigwell, K., & Taylor, P. (1994). A phenomenographic study of academics' conception of science learning and teaching. Learning and Instruction, 4(3), 217-231.

Robert, J., Carlsen, W.S. (2017). Teaching and Research at a Large University: Case Studies of Science Professors. Journal of Research in Science Teaching, 54(7), 937-960.

Ruiz-Primo, M. A., Briggs, D., Iverson, H., Talbot, R. & Shepard, L. A. (2011). Impact of Undergraduate Science Course Innovations on Learning. SCIENCE, 331, 1269–1270.

Smith, M. K., Jones, F. H. M., Gilbert, S. L., Wieman, C. E. (2013). The Classroom Observation Protocol for Undergraduate STEM (COPUS): A New Insturment to Characterize University STEM Classroom Practices. CBE—Life Sciences Education, 12(4), 618-627.

Terenzini, P.T., Wright, T.M. (1987). Students' Personal Growth During the First Two Years of College. The Review of Higher Education, 10(2), 259-271.

The Carnegie Classification of Institutions of Higher Education. Carnegie Classifications | Basic Classification.

Tian, M., Lu, G. (2017). What price the building of world-class universities? Academic pressure faced by young lecturers at a research-centered University in China, Teaching in Higher Education, 22(8), 957-974.

University of California Office of the President (UCOP). (2018). Academic Personnel Manual (APM) 285.

University of California, San Diego Institutional Research. (2022). Undergraduate Student Profile.