

Benefits of pre-lecture assignments and inquisition based learning in comparison to  
traditional lecture modes in science education.

A Senior Project

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Bachelor of Science

by

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## **Abstract**

Experiment was an assessment of the efficacy of two different teaching styles: traditional lecturing and a question based approach. In a traditional lecture class students frequently come to class with little or no previous exposure to the lecture topic. This may limit comprehension, retention, and the development of critical thinking skills. The questioning approach we used involved flipping the classroom where students were expected learn the lecture material at home by answering a comprehensive list of questions from textbook chapters. They were expected to come to each class period prepared to engage in a discussion of the subject matter, prompted by similar questions from the instructor. Our hypothesis was that the questioning/discussion format would improve comprehension, retention, and the development of critical thinking skills as well as improve focus of students during the class period. We expected that students would spend more time out of class mastering the material that they do in a traditional lecture class. Our experiment involved two sections of an upper division Evolution class (BIO 414) where one section was a control and taught through lecturing and the other the questioning approach. After the halfway mark the classes switched modes to give each section exposure to both modes of instruction and to limit bias (because every class is different). Success of the teaching style was gauged by formal assessments (weekly quizzes and tests) and informal classroom observations such as texting, talking, and asking higher-level questions. Formal assessments showed marginal differences between instructional modes, which may have been due to structural issues with the way we executed the experiment. However, students reported

studying 2x as much outside of class during the questioning mode. Results also showed that students in the questioning mode were more attentive, texted less, and had more questions during the class period. Student surveys also showed that the students knew that the questioning method was better for their learning regardless of whether they preferred that mode.

## **Introduction**

Preparing students for the real world is a top priority for educators. Among those skills that make successful students and citizens is critical thinking. In education there are many different teaching styles, strategies, and modes that educators use to get their students to learn. Our question is whether there are modes that are better for than others for engendering critical thinking skills. Our focus was on Biology science education. Science has been taught for a long time with a traditional teaching strategy of lecture followed by assignment. Currently most teachers appear to be more focused on teaching facts and definitions of science from textbooks with little emphasis on applications of scientific knowledge or on higher-level thinking skills (Gallagher 1987). Unfortunately the traditional lecture mode is not encouraging students to engage in higher-level thinking by focusing on defining vocabulary words and answering basic questions.

All students learn differently. Having all students in a class learn material from a traditional lecture, expecting every student to be able to comprehend the information and do an assignment on that material is unreasonable. Some students are auditory learners, kinesthetic learners, visual learners, or a combination. The traditional lecture strategy is not teaching all students evenly. With a flipped classroom, students do most of the

learning at home and then come to class to have concepts reinforced by the instructor. According to Nancy Warter-Perez and Jianyu Dong, “the fundamental idea behind flipping the classroom is that more classroom time should be dedicated to active learning where the teacher can provide immediate feedback and assistance.”(2010) This philosophy is summarized by the phrase, “guide on the side not sage on the stage.” Additionally, since the workload is at home students can take advantage of their best learning style and apply it to the material at their own pace. A consequence of flipping the classroom leads to students coming to class knowing the material, or at least knowing specific difficulties and questions about the material, and can engage in a discussion style class without any information going over students’ heads.

One problem with the pre-lesson assignment and discussion-orientated class is that some students will not participate. They will treat this class as a traditional lecture method class, not do the readings, and benefit from the other students’ discussion answers. A way to fix this is to make class participation mandatory. At each question portion in the lecture, the teacher will call on students randomly to give their answer and begin the discussion process. The student that is called on is responsible for at least giving it a genuine effort for real participation points. This will encourage the whole class to keep up on the readings and come to class prepared to answer every question.

Overall the teaching style that allows students apply their own learning style to the material, come to class prepared, be able engage in a discussion, and learn critical thinking skills would be the better teaching method. I had an opportunity to design and test this style in Dr. Knight’s Evolution 414 class where one section was taught with the traditional lecture mode, as a control, first and the other with the questioning mode first

and they switched at the midterm to reduce potential bias. Formal and informal assessments were used to gauge the benefits of both modes.

## **Hypothesis**

The questioning/discussion format will improve comprehension, retention, and the development of critical thinking skills as well as improve focus of students during the class period.

## **Methods**

In order to test this hypothesis California Polytechnic State University San Luis Obispo's College of Science and Math's Evolution Class (Biology 414) with Dr. Charles Knight was designed to be taught in two different ways: One section (Monday/Wednesday noted as MW) started with the traditional lecturing mode (noted as L), the other section (Tuesday/Thursday noted as TTh) started with the experimental questioning mode (noted as Q). The lecturing mode: Dr. Knight taught his class on a new topic every lecture that they had not heard before, and did not hold them accountable for any information besides from topic covered in previous classes. The questioning mode: Knight assigned a question-set for students to answer on the next lecture's topic as their pre-lecture assignment, then for the inquisition based learning portion Knight used that question-set to structure a facilitated discussion with students to answer questions for required participation points.

In order to assess each class formally on their response to the teaching mode there were seven quizzes, one midterm, and one final. Classes switched mode halfway (after

midterm) to eliminate bias because every class is different and both sections should be exposed to both modes. In addition to formal assessments, observational data was obtained one class a week for each section all quarter. I made observations in the back right corner to maximize visibility, because most people are right handed and I could see more text messaging on cell phones. During observations I looked for mostly student behavior that would correlate with paying attention, grasping concepts, and higher level thinking. Those behaviors included: Texting during class, Being unfocused or distracted (i.e. on the internet not pertaining to class), Talking which is a subset of distracted (more than asking a peer one question), Student-instigated questions as an indication of critical thinking, and questions asked overall to make sure concepts were being comprehended.

To get information from the student perspective student surveys were conducted at the midterm and final to gauge the two modes on which students preferred and which they felt was more beneficial, along with how many hours they spend studying for each lecture.

The data will be analyzed by comparing the formal assessment grade averages to see if there is a correlation between teaching mode and higher grades. However total grades of each mode cannot be compared because of the inherent differences on the chapters taught which could lead to bias. Observations will be analyzed by comparing the average overall frequency of student behaviors to see if there is a significant difference in each class with each method, by dividing the number of instances of each activity by the number of students in that class and averaging out all those numbers. Survey data will be compiled into a percentage of preferences to compare the change in each section's opinion on the modes before and after they are in each one.

## Results

The observation data was calculated and shown for texting, talking, overall questions asked, and student instigated questions asked. In the lecturing mode instances of texting were significantly higher on average (**Fig 1.**). Monday/Wednesday section kept the same high average frequency of talking while Tuesday/Thursday section was slightly higher but not significantly higher during the questioning mode than the lecturing mode, which was not what was expected (**Fig 2.**). This could have been the result of students not worried about being responsible for specific answers and they did not need to ask each other for help. As expected students asked more significantly questions overall in the discussion based Questioning mode for both sections (**Fig 3.**). Also as expected the questioning mode had significantly higher number of student instigated questions (**Fig 4.**), indicating that this mode promotes higher-level thinking.

The formal assessments were graded and averages were calculated. Only four of the nine formal assessments had a significant difference, one of which the questioning mode was higher (**Fig 5a.**). The main differences were between the sections not related to the teaching mode that they were in at the time, which was not what was expected. No significant difference between the two modes (**Fig 5b.**), which is expected because each sections were exposed to both modes.

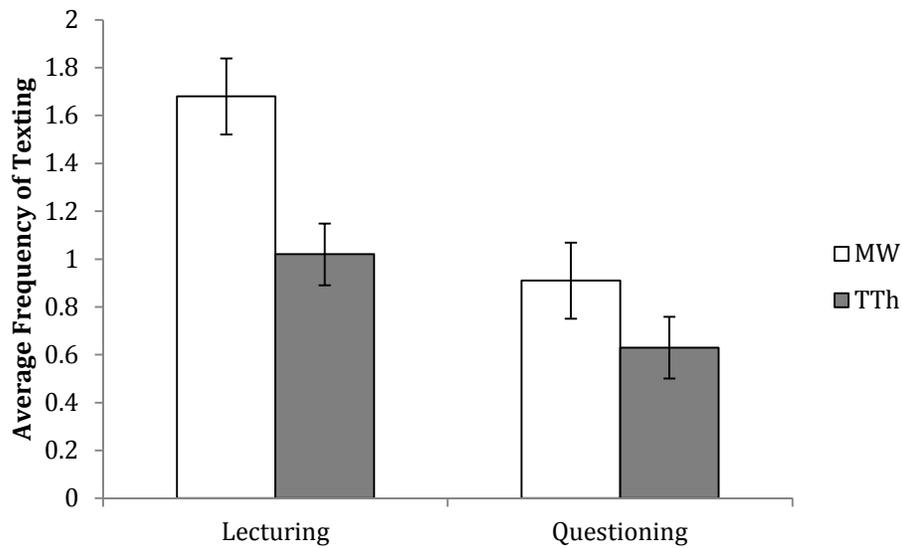
Students' preference and opinion of the teaching modes were assessed with a survey in each mode. Monday/Wednesday initially preferred the traditional lecture mode and after the switch it became a 50:50 split (**Fig 6a.**). Tuesday/Thursday preferred the questioning mode with a higher percentage than M/W for both halves of the quarter (**Fig 6a.**). It would appear that students prefer the teaching style that they start with and

switching halfway can be unfavorable. The questioning method, according to the students, is more beneficial than the traditional lecture method even though half of them dislike doing it (**Fig 6b**).

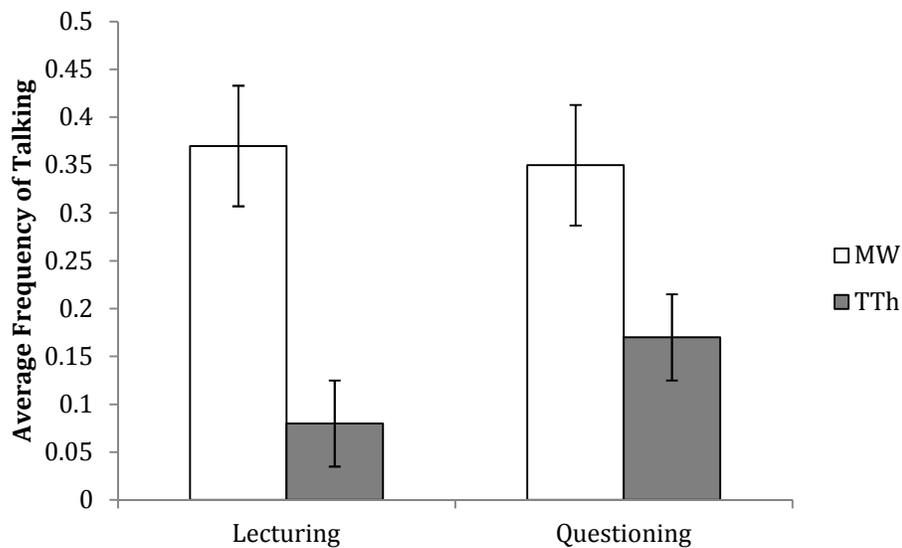
Average number of hours spent studying for each class meeting was averaged for each section for each teaching method. For the Monday/Wednesday section they reported studying 2.6 hours (0.5 hour min and 5 hour max) for the lecturing mode and 3.02 hours (0.3 hour min and 8 hour max) for the questioning mode. For the Tuesday/Thursday section they reported studying 3.25 hours (0.75 hour min and 10 hour max) for the lecturing mode and 4.4 hours (2 hour min and 7 hour max) for the questioning mode. Both sections reported studying more for the questioning mode, M/W added an average of 0.42 hours in the questioning mode and T/Th studied an average of 1.15 hours longer when in the questioning mode.

At the end of the quarter students filled out a teacher evaluation for Dr. Knight and he allowed me to include this in with the data. The Monday/Wednesday section gave the class an overall rating of 2.62 out of 4.0 with a standard deviation of 1.11, and the Tuesday/Thursday section gave the class an overall rating of 3.23 out of 4.0 with a standard deviation of 1.06. It makes sense that the class that started with the lecture mode and switched halfway to a harder and more challenging teaching mode, would give the class a poorer rating than the class which started hard and ended easier. Resulting in more evidence supporting the idea of not changing the core teaching style drastically halfway through the quarter.

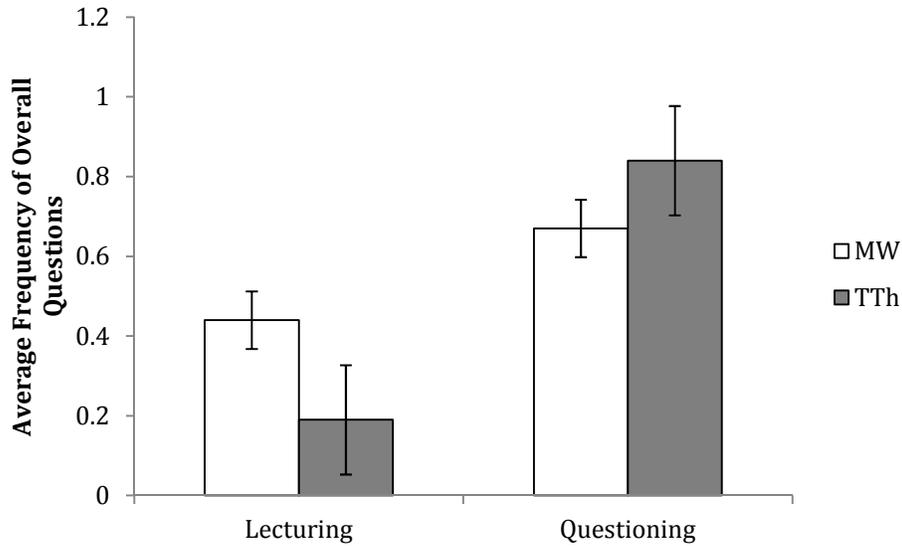
## Observations Data



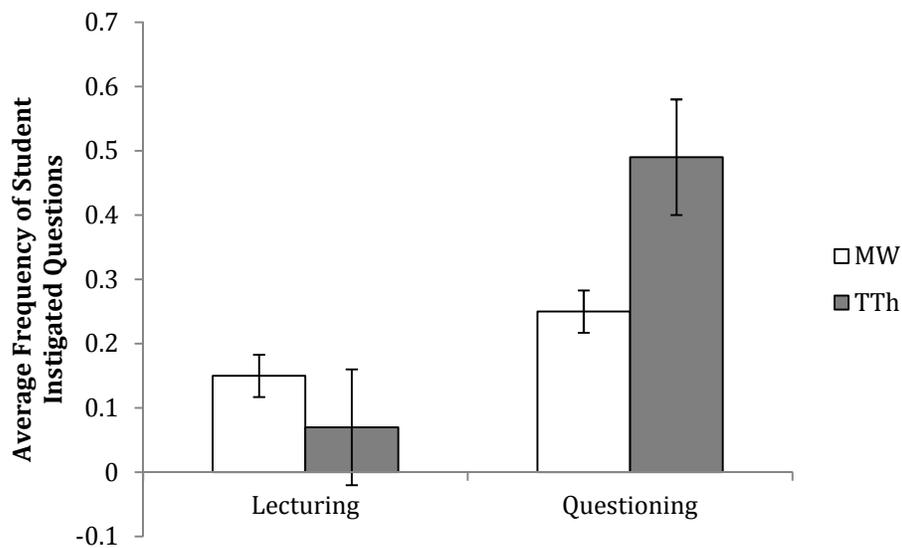
**Figure 1.** Average frequency of students texting (instances of texting/number of students in that day's class) show that the frequency of texting during the questioning format was considerably lower for both sections.



**Figure 2.** Average frequency of students talking (instances of talking/number of students in that day's class) that exceeded two back and forth interactions or unrelated to the topic. MW was a more talkative class unrelated to the teaching mode, and TTh talked more often in the questioning mode.



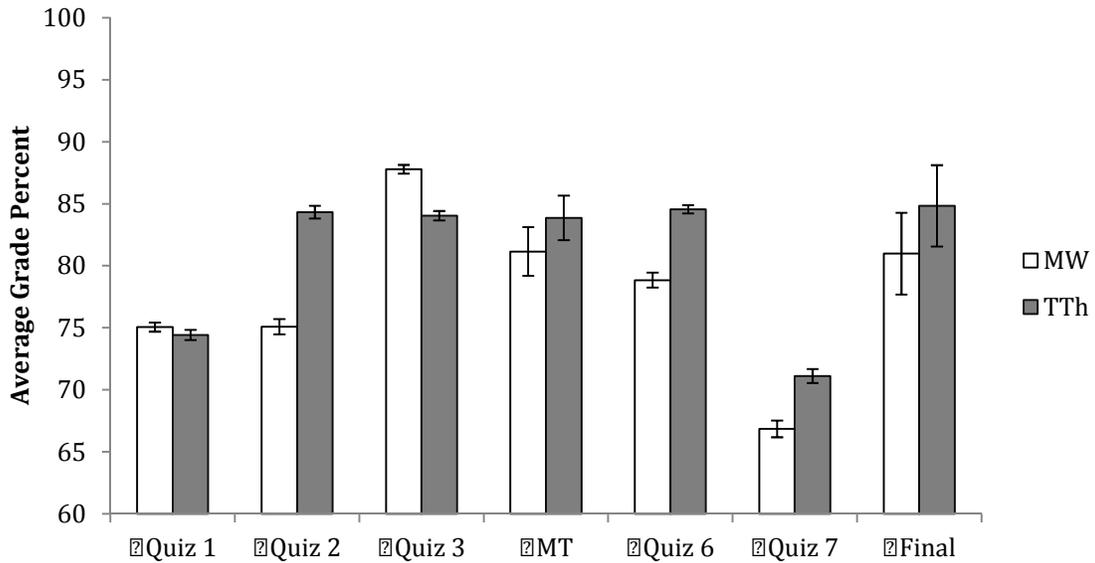
**Figure 3.** Average frequency of student instigated questions (instances of student instigated questions/number of students in that day’s class) were higher for each section in the questioning mode, however the TTh section had a much higher frequency.



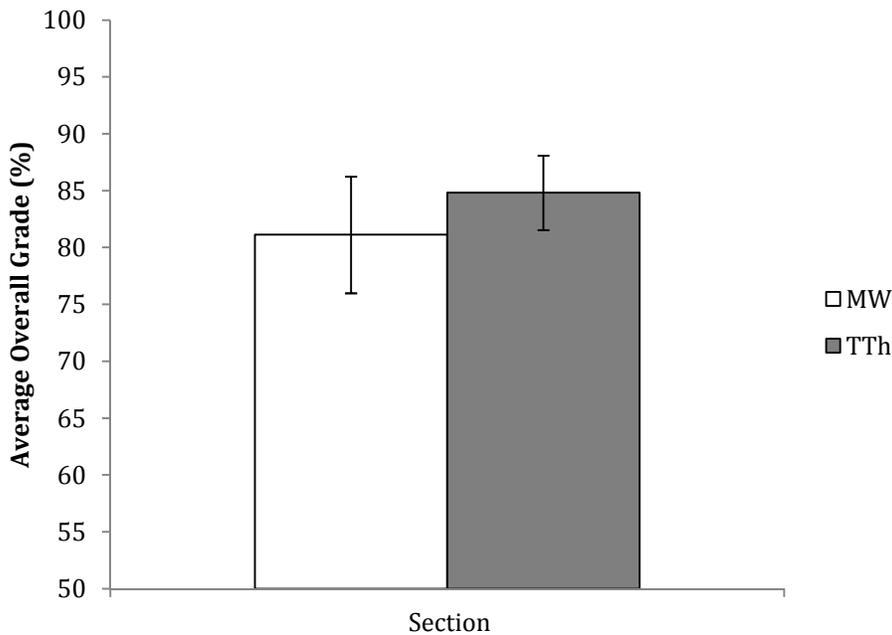
**Figure 4.** Average frequency of overall students questions (instances of overall student questions/number of students in that day’s class) was similar to student instigated questions, much higher for the questioning mode.

## Formal Assessments Data

a.



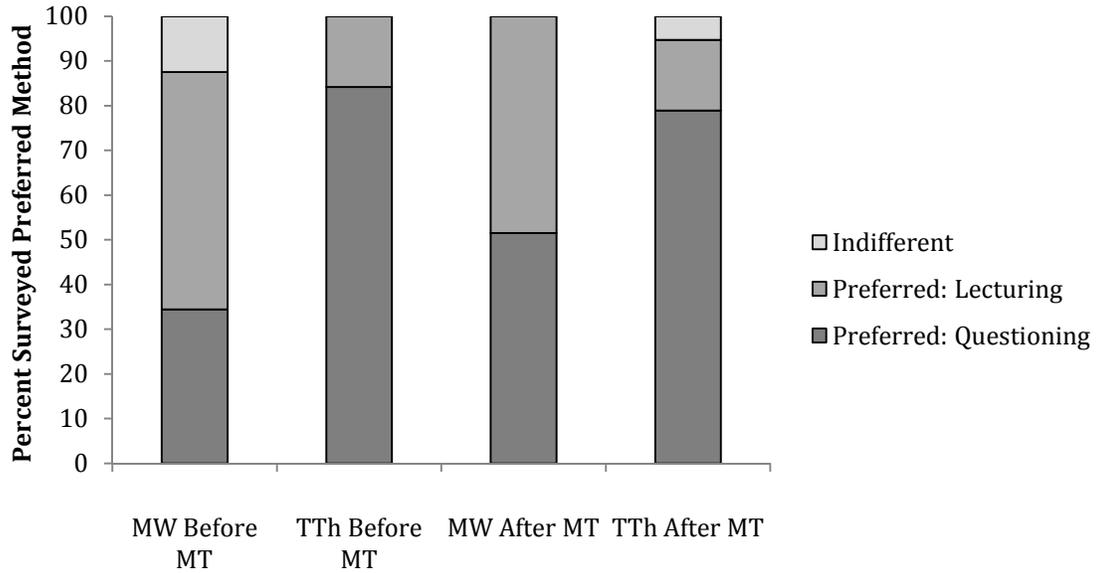
b.



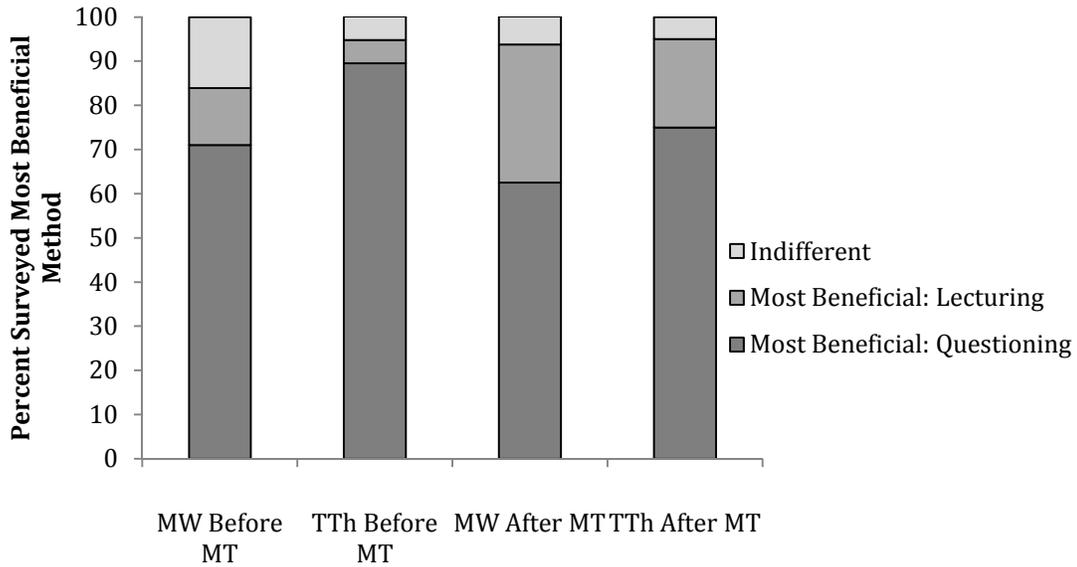
**Figure 5. a.** Average grades of each section on each formal assessment. Quiz 4 and 5 are omitted because of a grading error. Before the midterm there is no one better mode, after the midterm, including the midterm, the Tuesday/Thursday section got higher averages, two of which were statistically significant due to having longer exposure to the questioning mode. **b.** Average final grade was higher for the Tuesday/Thursday section, but not statistically significantly.

## Survey Data

a.



b.



**Figure 6.** Each section was surveyed before and after the switch in modes. **a.** The preferred method of learning was asked and MW preferred lecturing more and then became a split decision, TTh preferred questioning before and after the switch remaining consistent with their preference. **b.** Students were asked to select the mode that would be more beneficial to their learning and majority of all students in both sections before and after the switch agreed that questioning was more beneficial to their learning of the subject matter.

## Conclusions

Educational studies are extremely difficult. There are many variables and a study like this needs repeating. However interesting conclusions can be determined based on this experiment's data:

Formal assessments indicate that the two sections were not statistically significant from each other. Tuesday/Thursday section, which started with the questioning format, did slightly better overall and had more instances of higher class averages than the Monday/Wednesday which started with the lecturing mode. The observational data showed that either section in the questioning format had fewer instances of text-messaging, indicative of being more focused to the lesson. Additionally both sections in the questioning mode had greater frequencies of questions asked in class, which correlated to more participation and increased critical thinking. Data on talking in class showed a higher frequency of talking for the Tuesday/Thursday section in the questioning mode than the lecturing mode, which could be due to the discussion format in a smaller more intimate class. Student surveys show that students of each section mostly preferred the teaching mode that they started the quarter in, but knew that the questioning mode was more beneficial to their learning the concepts. Students in the questioning method studied more on average per class than the traditional lecture method. Overall the questioning mode is more beneficial in keeping students focused, on top of their work, and prompted higher critical thinking skills according to the frequency of student instigated questions in each mode (**Fig 4.**). Possible sources of error in this experiment could have been letting the students know that there was an experiment in progress, and switching the teaching mode halfway could have spanned multiple quarters instead.

### Literature Cited

Gallagher, J. J., K. Tobin. 1987. Teacher Management and Student Engagement in High-School Science. *Science Education*. 71(4):535-555

Miri, Barak, Ben-Chiam David, Zoller Uri. 2007. Purposely Teaching for the Promotion of Higher-order Thinking Skills: A Case of Critical Thinking. *Research in Science Education*. 37(4): 353-369

J. Dong and N. Warter-Perez, "Improving Collaborative Project-based Learning in Digital Engineering Based on Program Assessment," *Proceedings of ASEE Annual Conference*, 2010.

Rop, C. J. 2003. Spontaneous Inquiry Questions in High School Chemistry Classrooms: Perceptions of a Group of Motivated Learners. *International Journal of Science Education*. 25(1):13-33

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