UNIVERSITY OF CALIFORNIA

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Certificate in College and University Teaching Portfolio

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by

Michael Ford

Materials Department

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Teaching Philosophy Statement

Every time that I teach I feel I am giving something back to everyone who has taught me. As a student, as a researcher, even just in my day-to-day life, I am grateful for all that I've learned from others. Throughout my career, I've used learning opportunities to learn how to teach – lessons that I hope will continue throughout my teaching career and help me become a better teacher. My experiences thus far have shaped my teaching philosophies; I've asked myself, what were the moments in the course of my life where I've done my best learning? That question will guide me in thinking how students learn. My best learning came about when the teacher was engaged and eager, pushing her curiosity and passion onto me, even if I initially had no interest. I learned best when I was able to learn in multiple ways, like by first hearing the material in lecture and then later exploring the topics in hands-on activities on my own. Finally, I found that learning should be challenging, whether you're a beginner in a topic or you think you've mastered the course material.

My high school chemistry teacher was memorable, to say the least. She was famous around school, even with students who didn't take her class, for her enthusiasm for the subject and her desire to teach. As a student, I wanted to learn from her because I could see that she wanted to teach, and I now desire to imitate her enthusiasm in the classroom. It's not just about coming up with funny songs to memorize key facts, like she did, but it's also about expressing to the students that you want to help them learn. As a teaching assistant for an undergraduate chemistry course, I thought about her teaching and tried to be as excited as I wanted my students to be about the course material, even putting on my best sing-song voice and reciting one of the rhymes that my chemistry teacher taught me a decade earlier. The fact that I still remembered how it went showed how effective it was; I've seen how enthusiasm can influence students' willingness and ability to learn.

All students don't learn a topic just by listening to a single lecture. Much of my time in graduate school was spent doing research on a very specific topic, and now, my thesis area is what I have learned the most about. I've developed deep knowledge of my field through my research, now able to recite statistics and property-structure relationships without a second thought. But my research wasn't the only way I learned about my field: I also attended lectures and applied background knowledge to solve homework problems; my learning was diverse. By diversifying my teaching style and including activities that promote exploratory learning, as an example, I was able to facilitate discussion and leave lasting impressions on high school students who took my polymer course in the School for Scientific Thought at

UCSB. In my future teaching, I hope to continue to access different styles of learning so that my students will be successful.

Learning should also be challenging. A struggle, not one that is too discouraging, can solidify and reinforce knowledge. As a student with a chemistry background, I once taught a discussion for Materials 101, a course in the engineering department. Crystallographic planes and Miller Indices; Fick's Laws and diffusion; Metals, composites, ceramics, and polymers; stress and strain; yielding and fracture; phase diagrams and cooling curves – some of these concepts that upperclassmen engineering students were expected to know I only had a slight familiarity with, and some were as new to me as they were to some of the sophomore and junior undergraduates in my course. My discussion section was on Mondays, and there were a few Sunday nights that I was up late, struggling while trying to learn the material, looking up supplementary information online, and writing and re-writing my notes. During discussion, when we would go over the homework, I felt I could better lead students to the answers rather than give them the answer, since I struggled through the work just like they were struggling. Through that struggle, I learned. I found that I needed to prepare, re-prepare, and prepare again so that I truly understood the material, and I make it a point to really have a deep knowledge of the subject that I want to teach; it's not easy to learn in this way, but it's effective to be able to teach when you have a deep knowledge. As a teacher, it can be difficult to challenge all students; some students come in already knowing most of the course material while some are lost by the end of the first lecture. I need to know the material well enough so that I can recognize when someone has grasped important concepts and then provide them with the next steps to keep them engaged in the content, and I need to know the material well enough so that I don't stutter over key concepts and cause students who are already lost to feel even more confused. It's important to find ways to challenge all students and being prepared will help me do so.

Through teaching, I learned the importance of not just focusing on how I learn but also of acknowledging how others may learn differently. If there's anything I've learned through my career, it's just how much I don't know. Through pedagogy workshops, outreach, and courses I've taught, I've learned important strategies that I have implemented and will continue to develop throughout my teaching career. Specifically, one very important strategy is setting a course goal and individual lesson goals. This has helped me stay on track while teaching, especially since it's so easy to get caught up in the flashiness of exciting demonstrations and let the students miss the point. Another strategy is about when and how to ask questions that keep the students engaged, something that I am currently working on. It is easy to get into a flow of talking and forget to ask questions. That is why I will start to intentionally plan questions in my lesson that the students will have to answer. To access whether my methods are working, or whether students are learning (or not learning) differently, I learned that I need to measure and assess students' learning. This should be done at different levels throughout my teaching with open questions in class, regular quizzes/homework, and comprehensive testing where applicable. I'm still experimenting with what works best: for example, daily quizzes might be useful for assessing my own progress but might stress the students out. But even after learning such strategies, I must acknowledge there is still a lot to improve upon. By continuing to grow and accepting change, by adapting and reacting to new climates, by embracing the diverse group of students that I'll teach, I will continue to develop as a teacher. I know I will keep an open mind. In that way, I can foster curiosity in science and help grow the next generation of great learners.

Requirement #1: TA training

There is one thing that stuck out to me from the campus-wide TA training at UCSB: look at the chalkboard after you finish writing notes for your students. It might seem like something mundane, just some small detail in the handful of seminars and discussions on teaching that could easily be neglected. But of all the teaching tips; the introduction to new methods of discussion and instruction; the advice on how to prepare mentally and emotionally for teaching, this is the one that I have remembered the best. And it wasn't that it was just something I knew I needed to work on (it was – at best, my handwriting is still sloppy, and I can easily get lost and disorganized on the board, further confusing students who might be struggling to follow along) but it was more that it spoke to a deeper need to ensure my teaching success. I needed to prepare beforehand and make sure everything that my teaching is clear to the students.

I actually wrote a blog post after my first day of teaching; looking back on it now, with the hindsight on how the rest of that quarter went, I can see that I was pretty proud of how I did. It was the first class I was teaching on my own, and I had my own discussion session: 50 minutes to hold the students' attention and reinforce concepts taught in class. In the blog post, I mostly discussed how the discussion went well – uneventful it seems – and how my desire to teach was reinforced. I seemed well-prepared and even managed to overcome some technical difficulties when my laptop didn't work with the projector. The ideas from the TA workshop must have influenced me, leading me to spend some time before the course and prepare well, or so I thought.

The first challenge in teaching came not a week later. The concept of molecular weight of polymers was being taught, and even now, thinking of how to describe it in this reflection, it's not a clear concept. I've heard it described with various analogies – cars and population and grades – but nothing really stands out as intuitive. Still, I decided to use a population analogy that I read on a polymer teaching resource online. It said to take the average population of various cities: Memphis, TN: 700,000; Montrose, CO: 10,000; Effingham, Il: 12,000; Freeman, SD: 1,500. If you take the standard definition of a mean, 180,000 is the number you get. But that doesn't really represent the average size of the city that the average person lives in (if that is something you want to consider); 97% of the total number of people in those four cities live in Memphis. Thus, a weighted average, incorporating the total number of people might be necessary to answer a specific question (e.g, maybe the question relates to what city is more likely for a person at random from this population group to live in.) Anyway, this long, nearly irrelevant discussion just proves my point: it's not a simple concept to remember. I tried to extend the analogy and make up my own, practicing it just once before lecture. Once I was in class, I felt an overwhelming feeling of panic that I hadn't practiced it enough; I was looking at my chalkboard and I could see and feel that it was no longer clear what I was talking about. All I could do was tell the students that I didn't prepare well enough and that I would email them to clarify the confusion.

I did email the students and tried to explain my mistake, but for some students it might be hard to overcome their initial confusion, and perhaps, some lost faith in me as a TA. I vowed to not let that happen again. I studied the course material, practiced the homework sets on my own (as if I was actually taking the class), and really looked at my chalkboard (metaphorically and literally.) **Appendix 1** demonstrates this: in the first week of the course, I merely printed out the homework with the solutions so that I could help students, if any questions were asked, just by looking at the answer key and hopefully understanding immediately a way to lead the students to the answer. By the second week, after I learned that this sort of improvisation would not work, I printed the homework without the solutions and worked the problems on my own before the discussion session so that I could better understand what each student might struggle with. **Appendix 1** shows my notes, made just for myself so that I could ensure I had a grasp on the course material. In discussion, I started focusing more on how I could get the students to the point where they understood how to solve problems related to the course. Still, I needed another reality check in my next TAship to further emphasize the importance of being prepared.

The next year, I attended the department-wide chemistry teaching workshop, which ended with each student giving a short lesson on a chosen topic. The new graduate students in the chemistry department, eager to show their knowledge of the topic, included in their lecture long descriptions of chemical phenomena and very interesting examples demonstrating intriguing chemistry principles. In comparison, mine was very dull and bland, focusing on what the students needed to do to complete the lab. Basically, I copied what was in the lab report introduction and methods and condensed it into something the students could learn in about 10 minutes. I was commended for how poignant my discussion was, on-topic and illustrating the important concepts of the lab, albeit relatively boring. Of course, even just a little confidence boost like that can sometimes sway too far to the side of over-confidence.

I received feedback midway through the quarter and found out that some students, most especially in my first class of the week, were not enthusiastic about how I prepared for lecture. For example, one review read, "Make sure you've got the procedure down pat so you don't confuse us in a demonstration." I knew exactly what this student was talking about; the guilt over failing the students in such a way has really motivated me since to make a habit of adequate pre-preparation. For general chemistry, TAs teach three sections. Since I had three sections, I would prepare the day before or the day of lecture and give the lecture without much practice to the first class. The first class, I was treating as my rehearsal. I realized that that wasn't fair to the students. They were losing out on a better lesson because their schedule dictated it. By random chance, they were getting worse instruction for me. I thought back to my first class and to the TA trainings that I had taken, and I knew I needed to start taking my time with each section equally seriously. By the time I finished the course, I was writing and re-writing my chalkboard talk before presenting it the first time so that it could be clearer to the students. **Appendix 2** provides an example of this; the lesson plans were provided by the department's instructional team, but I rewrote the material so that I could understand exactly what I wanted my chalkboard to look like and ensure I was teaching the key concepts that I felt were important for the students' success.

These lessons are important for me to grow as a teacher, and I hope I will carry them with me as I continue my teaching career. Most importantly, after each lesson, I hope I can look back at the chalkboard and understand each point, and that the students will also understand. But not because my handwriting looks nice or because I made artistic depictions of scientific concepts using shading and 3-D perspective, but because I spent time in advanced preparing so that I knew the material well.

Requirement #1-1: ESCI Reflection

While considering these evaluations, it was important to me to consider the pitfalls associated with these sort of evaluations, which can be skewed by very unhappy or very happy students, for example. I also should keep in mind the response rate. The statistical significance of the results is also relevant; the average score may not provide any indications of my ability to teach (e.g., a teacher with a high number of above average and a high number of poor ratings would get the same score as a teacher with average ratings; the context is lost.) As an example of how scores may not reflect teaching ability or performance, I received a 4.93/5.00 on “The TA’s interest in enthusiasm in the subject matter” for teaching Materials 188. This was higher than the department average for that quarter (4.73) and for all of time (4.22) as well as for campus-wide over all time (4.49). However, it is my opinion that the scores would have been high no matter my teaching ability because the students were happy: it was a survey course with easy homework and no tests except for a final and most students, if not all, received an A.

It should be noted that 45% (5 students) and 36% (4 students) rated “Excellent” and “Very Good” for “The TA’s interest and enthusiasm in the subject matter” and 45% (5 students) and 27% (3 students) rated “Excellent” and “Very Good” for “The TA’s interest and enthusiasm for teaching.” These seem like good scores, but there are two points I should consider: 1) one student comment that said “Section was basically office hours. Actual material prepared and reviewed during section would have helped more. More examples would have helped more.” 2) And that the scores themselves were below average for the quarter for Materials TAs, average for over all time for Materials TAs, and below average for all time for Campus TAs. Granted, the scores are asking about my enthusiasm rather than teaching ability or overall performance, so they are limited in their scope (but enthusiasm is a topic that I value in my teaching philosophy.) However, while it’s good to be critical of the scores and their meaning, I shouldn’t use that sort of analysis as a way to justify my poor scores. I was new to teaching and needed to improve (as I still do.) In particular, the student’s comment about the office hours was pertinent. In my weekly discussion, students mostly asked questions; I prepared a few limited examples, but my time was spent answering homework questions. Only if I had time would I go over other examples with the students. For those who had mastered the homework and were looking for challenges, I was not providing enough support. This directly relates to my teaching philosophy: students should be challenged. In similar situations in the future, I would prepare more examples that could scaffold students who were not understanding the homework while at the same time challenging students who were already ahead of the curve. If the scores truly reflected my enthusiasm, as the question was asking, then I also need to make that a priority in future courses, especially since it's also a major point of my teaching philosophy.

Given the quantitative nature of the student ratings of instructions, it was actually very informative to have three separate sets of ratings from students when I taught Chem 1AL, the first course of the general chemistry laboratory. It's also a unique outlook from the students; for most of them, it is their first laboratory classroom, and thus I was one of their first TAs. The ratings in this course are also useful because the chemistry department asks students to fill out midterm evaluations, so I can compare the midterm evaluations with my final evaluations. First I compiled the midterm and final data for the entire course (**Figure 1** and **Figure 2,** see **Appendix 3** for Figures for this section.)

For quantitative measurements, I converted the excellent to poor a-e scale to 5-1. The questions in the surveys were also different (**Appendix 4**; scanned sample surveys). The written questions are shown in bar graph labels of Figure 1 and Figure 2. For future feedback surveys, I should include the same questions on the midterm evaluation as on the final evaluation to better assist my improvement during the quarter. Still some aspects of my teaching can be compared. The scores were also presented to me differently in each case. For the final review, I was given a percentage of students that gave a specific response. I could not see whether some students gave me all "excellent" ratings or a mix. For the midterm review, I was able to see the exact scores each student gave. In these cases, I could eliminate the students who gave all top scores, with the assumption that these are students who are just happy with the course/grades. Since there is always room for improvement for my teaching, perfect scores across the board aren't likely a reflection of my performance and thus the results may not be able to help improve my teaching (**Figure 3**.) Both ratings with and without perfect scores are being considered for full evaluation.

Starting with the midterm data, I am happy with the quality of my scores. In the case of the midterm scores, I have no metric to test against (e.g., vs. the entire department or university.) In addition, I could only be giving good grades and students are happy about that. There were weekly quizzes, and I tried to make them challenging for the students. If I look at my final evaluation, I see that "Fairness in grading" (discussed later) is one of my lower scoring categories. Also, a significant number of specific, hand-written comments on my weaknesses (8/25 comments that were not left unfilled or marked N/A or similar) identified quizzes and grading as a major issue. Thus, it is unlikely that my scores were skewed toward easy grading. This brings about an interesting point: I can balance and dissect my desire to be liked as an instructor and my desire to be a good instructor. I sometimes worry about grading and might lean toward making homework assignments or tests easier. But upon reflection, I can see that if I want the course to be challenging I can do that, and the students would still be happy with my teaching abilities.

I also need to consider areas of improvement, even if my scores are high. By removing the students who gave all perfect scores, I can see more glaring issues. Note that in Figure 3, the rating of how I "encourage class discussion" is substantially reduced when removing perfect scores. This is something that relates to my teaching philosophy future goals: I need to build in lesson plans that incorporate class discussion and questions. It's noted that a few specific comments also listed my lack of class discussion as a weakness. The other aspect of my teaching that was reflected when removing the perfect scores was my enthusiasm; I can see how students might think my enthusiasm is low. When speaking in front of large groups, I find that the feeling of nervousness and excitement elicit similar physiological responses in me. If I get too excited, I might start to think I'm nervous and might be more likely to mess something up. Therefore, I try to keep my voice calm and collected when speaking. This is something I need to work on as an instructor. I tried this later in the course: I sang a song as a mnemonic device in front of students. It felt embarrassing, but most of them won't remember it as embarrassing and some might even remember it as useful, like I do. I feel the need to force myself to engage the students in this way more. I will note, however, (not as a way to avoid responsibility for low enthusiasm scores) that some students wrote enthusiasm as a strength. Still others wrote it as a weakness. Thus, it seems a very hard aspect of teaching to define: does "enthusiasm" mean I like to be there? (e.g., I'm rushing students out the door as soon as class is over.) Or does "enthusiasm" mean I express a willingness to help via email, in my free time, if students need? Or does it require me to be goofy/charismatic, or bring up exciting new results in my field of research, or tell a joke to start each lecture? I think all of these aspects of enthusiasm can have a place in the classroom, and where my deficiencies lie could be answered by future feedback surveys that are designed to elucidate the meaning of enthusiastic teaching.

I can also compare my final scores to campus-wide scores. My final scores are compared here to all TAs over time by normalizing (**Figure 4**.) A value > 1 indicates a higher score than the average campus-wide score. In all categories, the normalized values are greater than 1. This is good, but should be considered the minimum. As someone who wants to be a good teacher, I should score higher than the average. To utilize this data effectively, I can look at the scores that are closest to 1. Most alarming is my discussion and enforcement of safety procedures. I don't recall any specific incidents, except a mistake by the stockroom in one of the three labs where a greater-than-expected concentration of solution was given and caused reactions to bubble more violently (but not dangerously) than expected. I would assume that the students would distinguish that incident as unrelated to my performance, so I should take into account safety in the future. The blackboard presentation is also much lower than I would want. Many students gave specific comments on poor handwriting, which is a problem I know I have. I can write slower and prepare my notes clearer to improve upon this.

Another very important lesson that I learned in this reflection is that I need to prepare adequately before my first class. It's not fair to students who happen to have me early in the week to receive worse instruction than those who have me later in the week. By separating the scores for each class, there is a trend of upward increasing scores as the week went on (**Figure 5**.) This may not be statistically significant; the standard deviations are on the order of 0.1 or greater, but it is still a point to consider. I should give equal opportunity to all classes that I teach.

Finally, the specific comments provide valuable information about what the students' needs are and how I can improve to fulfill them. I used specific comments to critically think about how I can improve: I need to be engaging more in my lecture (tone and content); I need to encourage discussion; I need to consider how students are responding to their grades. I could also look at areas that appear important to the students. Many students said that my strengths were speaking clearly and demonstrating the laboratory; in this case, I feel that is the bare minimum. Some were appreciative of the time I took outside of class to be of assistance. I want to make sure that students do feel that I am available to help. By creating a word cloud of the strengths and weaknesses that the students were asked to consider, I can get an aggregated view of what the students find important (**Figure 6**). For the strengths, it's clear that students emphasized the concepts and course material; good and clear explanations also seem important. For the weaknesses, what stands out is participation and quizzes, along with the words hard and difficult. I'll note that one larger word in the weaknesses is "hearing", which was amusing to me (since they are saying my weakness is my disability) but also a real concern: I have hereditary hearing loss, and that's something that I need to manage in the classroom. I've found ways to deal with that, by having students write things down or by having a student nearer to the front of the classroom "interpret" for me so that I can hear.

For my next course, I want to focus on four specific items that came up in this reflection: 1) encourage class discussion by integrating specific questions into my lecture 2) continue to challenge students with assessments but also directly discuss grades with those who are receiving lower scores so they don't feel lost or confused about their low performance 3) slow down chalkboard talks to keep lecture legible 4) dictate enthusiastically and assess what aspects of enthusiasm are missing from my teaching styles. With those specific examples, this exercise proved very valuable. Hopefully, in the future, I can continue to reflect on student scores and use them as an evaluation and improvement tool.

Requirement #2: School for Scientific Thought

Lost in the course description of the School for Scientific Thought was the focus on "designing goals, formative assessment, variety of instructional techniques, and communication." I saw the words "design, teach, and evaluate a hands-on course" and instantly thought of all the wow-factor demonstrations that I could show the students. One quarter of TAing and the pedagogical workshops did not engrain in me enough how important defining a specific course goal is.

As in the case of my first week as a TA, I also wrote a blog post about my first few weeks as a co-instructor for a course on polymer science and engineering through the School for Scientific Thought. In that post, I wrote specifically that the "goal of our course" was to "show how changing the structure of a polymer (from individual atoms to how chains are arranged to how blobs of polymers interact) can change physical properties." This is a very clear goal that I could always revert to when teaching the course. But I did not initially know how important it was to set a clear course goal. Anne Emerson, a graduate student in the education department at the time, was a partner with the School for Scientific Thought, and she helped us structure our course. She taught us how important it was to have a specific, overarching goal for our class, and that if we were ever stuck in the middle of a lecture, we could always try to tie what we were teaching back to that goal.

There are so many scientific demonstrations and activities that are engaging, fun, and stimulating but it's easy to get lost in the excitement. Through my instruction in SST, I found that presenting concepts in a coherent way can just as important as engaging the students with good activities/demonstrations. In our original plan, it felt almost wrong to expose the students to lecture and quizzes; the students were coming on a Saturday, our thinking went, so the class should be fun! We wanted to design a lab session where students could mix chemicals together to make the polymer that makes up Silly Putty. It's a simple synthesis and can be done with conventional glassware available in a chemistry classroom. The chemicals are not prohibitively expensive, but they are considered dangerous enough that they have to be handled carefully in a cleanroom. Many students had worked with gak (glue and Borax) or oobleck (corn starch and water), which don't require any dangerous chemicals or even any specialized equipment. My idea to have the students synthesize Silly Putty was one born from a desire to show-off exciting science that can't be done safely at home. I didn't have a clear takeaway message for the students in mind before we taught the class. The School for Scientific Thought emphasized the importance of our course goal, and we were able to use the Silly Putty lesson to show how changing the structure of the polymer (by crosslinking, in this case) changed its properties (from an oil to a stretchy, bouncy, rubber-like polymer.) There is a place for "less fun" things about teaching; e.g., conventional lecturing can be useful to teach simple concepts to a large audience and quizzes are not just to test the students' knowledge, but they also provide feedback for the instructors. I had to focus more clearly on what I wanted the students to get out of the class, besides just an enthusiasm for science and engineering.

In helping us design our goals, Anne introduced us to Bloom's taxonomy, which I now use when thinking about course goals. To me, Bloom's taxonomy was useful in distilling how students should learn and how I should teach. I initially had the perception that memorization, the base of Bloom's taxonomy, was almost useless. I thought that students should learn to think critically and that, especially in today's society, remembering could just rely on computers and phones and the internet. But Bloom's taxonomy clearly illustrates that memorization is the base for thinking critically. It allows students to classify, then interpret, then examine – all the way up until they can create by thinking critically. Not only was Bloom's taxonomy helpful in letting me see, especially visually, the importance of each aspect of learning, but it was also integral to helping me build lesson plans, and I still use it today. **Appendix 5** shows a lesson plan draft for my instructor-of-record course. Here, to clearly define the goals to myself, I used vocabulary from Bloom's taxonomy. By doing this, I now have an outline for the course, and if I am ever stuck or loss during a lesson, I can step back and focus on the key concepts that I want to teach.

Requirement #3: Technology in the classroom

In designing and teaching my own lab and lecture course for the Science and Engineering Research Academy, I had a lot of freedom in what aspects of technology I could implement in the classroom. I chose to do three main things that I had never done before: 1) use a personal response system to gauge students' understanding of key concepts; 2) utilize a variety of technological tools to diversify lecture; and 3) create and share a video-based lab procedural for students to reference during lab time. In doing so, I found that the personal response system helped me break up the pace of lecture by having deliberate moments in class that I would ask questions, and students felt that the practice questions helped on quizzes. Students had no issue with bouncing between media platforms to learn; it may be that different learning styles benefitted some students. The video-based lab procedure was not worthwhile for the course, and students did not utilize the lab procedure. Still, overall, technology in the classroom proved useful, and I hope to continue to have the chance to try more iterations of technological implementation.

The three technological changes that I made to my classroom included a personal response system, technological tools that would help with lecture pacing, and a video-based lab procedural. The personal response system that I chose to use was Socrative, after exploring other options such as iClickers (which would require students to buy and bring hardware) and Kahoot (which seemed useful for more fun activities, but I may try to compare someday). I designed a Socrative quiz each day and told students they needed to participate but did not have their scores tracked. I wanted to use multi-media as "lecture busters", so I designed each lesson to include at least PowerPoint and whiteboard work and also frequently used a doc-cam. A video-based lab procedure was created and used for one lab to try to help students follow along with difficult procedures. I spent time filming and editing, uploading the video to GauchoCast for students to access.

Socrative was straightforward for me and the users. It is a free online personal response system that allows the instructor to design quizzes, and students answer questions on their cell phones or laptops. All students (24) in my course had cell phones. Questions can be multiple choice or fill in the blank. Students can work in groups or alone and can answer questions anonymously if the instructor allows it. The responses are saved on the Socrative website and can be accessed later by logging in. I chose to require students to answer anonymously and answer questions alone. Most questions were multiple choice. Many students had already used a tool like Socrative before, with the first quiz including a question on whether students had used the tool or something similar before. Only 9/24 students had not used a mobile personal response system, but the tool was easy to learn. One of the challenges with technology emerged immediately, with this first question. I had tested the quiz the night before to make sure it would work, but when students logged in in the morning and answered, the quiz showed "0/0 responses". Therefore, I actually had to revert to a tried and true response method: having the students raise their hands. I later figured out that I could end the quiz and then access the reports, but this was cumbersome. Sometimes the quizzes would work, and sometimes they wouldn't; most of the time, I would just access the reports after each question but this was not preferable. I searched the internet for my problem but couldn't find a solution, although I started to correlate the issue with whether or not I had left my browser open since the last quiz.

Still, the tool was useful. Socrative provided a way to access the aggregate doubts or confusion that students were having and to understand how the entire class was thinking in real time. Research (Coca & Slisko, 2017) suggests that active learning can be easily achieved with technologies like Socrative. After using Socrative, students said they felt more involved in the lecture and discussions. Multiple researchers (Attewell, 2005; Kolb, 2011; and Duncan et al., 2012) have highlighted benefits of incorporating smartphones in class, including that cell phones can empower students who are visually or hearing impaired. In fact, it's also true that cell phones can help the instructor, who might be hearing impaired, like me. I often have trouble hearing students in class and will walk right next to their desk to answer a question for them during lecture, sometimes still failing to hear quieter students, which feels embarrassing for me and the student. Socrative made me more confident in asking questions because I didn't have to worry about not hearing students. Another success of Socrative related to daily quizzes, which were designed with questions that were identical or similar to Socrative questions. In a course survey, I asked students if they remembered a specific time where Socrative questions helped them on a quiz. 16/24 students said they agreed or strongly agreed that Socrative helped them on a quiz. 1/24 disagreed (remainder were neutral). In that future, I would continue to use Socrative and may also try to use it more to help with class communication if possible (e.g., for questions that students might have since I am hard of hearing).

Since many studies in the literature suggest that lecture should be broken up every fifteen minutes or so (although some argue that this may not always be true, Wilson & Korn, 2007), I used the doc-cam and PowerPoint, along with whiteboard work, discussion, and Socrative, to try to break-up the lecture as much as possible. Most lectures were conducted on the white board, and I would often switch to the doc-cam, which could be easily translated from white board work. Notes were hand-written with the doc-cam; the doc-cam was also useful for in-class demonstrations that were too small to be noticeable by anyone not sitting in the first row. To demonstrate surface tension of water on a penny, for example, I placed the doc-cam in view of the penny and the bubble that formed as I added drops of water so that the students could see better. Student engagement (subjectively) appeared high, even for this simple demonstration. PowerPoint was used to incorporate multimedia and as another way to present lecture. PowerPoint was mostly used to present videos, pictures, graphs, and diagrams at specific points in lecture.

Other lecture busters included switching to whiteboard work, Socrative, group discussions, and group activities but those will not be discussed as they have been covered or are not technology-related.

The limitations were related to my own preparedness; for the doc-cam, I came into the classroom before the first day of class to make sure I could use it properly. Only once did it malfunction, taking a long time to change over from my laptop that was projected to the doc-cam. This was a minor malfunction, and I was able to let the students discuss amongst themselves while the system transferred over. PowerPoint required me to prepare in advanced videos and graphics that I found useful, and there were no issues with these. I frequently used results Google News at the beginning of class to engage students in the topics that we were covering. One student asked me to continue to send news about polymers that I found, which may have been pandering or may have been general interest in this use of technology. A few times, I would arrive to the classroom with no blank white sheets of paper for the doc-cam. This was a problem in terms of breaking the lecture up, since I couldn't use the doc-cam (and didn't want to use lined paper that the students had on-hand as the contrast isn't great for drawings and long equations on lined paper.) However, I could still just focus on the whiteboard for the lecture.

In evaluating this technique, I found it made me think deliberately about my lecture content in advanced. What would students find more accessible on the whiteboard vs. doc-cam vs. PowerPoint? It also allowed me to think about how I was dividing the lecture up. How easy was it to package the content of the lecture into subsections? I found this to be very helpful in lecture planning and timing, although most of my lectures still were planned too long. However, I could easily stop at any of the ~15 minute points and start the next lecture where I left off since I logically separated that day's topics. In the course survey, I asked students 6 questions to evaluate if they understood the material taught through each technological tool; students were asked if they felt they learned well from lessons taught primarily on the whiteboard, doc-cam, and PowerPoint and if they remembered a specific time they were confused after a lesson taught on the whiteboard, doc-cam and PowerPoint. Students mostly agreed that they learned well from all three tools, suggesting that none were a distraction or unfamiliar enough to prohibit learning. Many students (21/24) had agreed or were neutral for all three tools in answering if they learned well; however, some students (3/24) had varied responses, disagreeing for one of the three tools that they learned well and agreeing/neutral for the other two. Although research suggests that learning style may not significantly influence preferred instructive technology (Young et al., 2003), there may be an insignificant number of students (e.g., in this case, 3/24) who would prefer one style or the other. However, while the choice of instructional tool for each lesson was random, one technology or another may have had harder lessons. When looking at whether students remember a specific time they were confused, many students (17/24 and 11/24) agreed that they were confused after a lesson on the whiteboard and doc-cam. Reflecting on the course content, more time was spent on the whiteboard, which may have selected for a confusing topic that was presented on this medium. 5/24 students recall being confused after PowerPoint lesson, which is much less than the other two media. This was most likely because PowerPoint was used as a supplement most of the time, rather than a major component of a lecture. Again, as with Socrative, I would implement this method of teaching again, primarily because it helped with lecture planning and might have kept students engaged. In the future, I hope to incorporate other technological tools as lecture busters and as a way to keep students engaged in the course content. One example might include computer modelling, which I had planned on doing but ran out of time as the course progressed.

A video lab procedure was designed, created, edited, and posted on GauchoCast, with student access through GauchoSpace. In advanced of the course, I filmed myself performing a relatively complicated lab procedure and edited the video. The video was filmed mostly from a first person perspective on my Nexus 5x and edited with a simple program called Wondershare Filmora. The video was uploaded to GauchoCast with a link posted on GauchoSpace. Students were not required to watch the video but encouraged in lecture and lab sessions to access the video before the lab. I intended to make a video lab procedure for all labs but scrapped that idea after the mediocre success of the first one. The video lab procedure was especially troublesome in the time that it took to shoot and edit the video. The intention of the video lab procedure was for students to be able to watch it in advanced and refer back to it during lab, especially if the TA and I were busy. The video is available to watch here:

https://gauchocast.ucsb.edu/Panopto/Pages/Viewer.aspx?id=79e233bf-41c4-40f8-8142-a90a013f9d98

Most of the concerns were with the logistics of the video, rather than the technology itself. I had experience with shooting and editing simple videos like the ones I planned on making so there was no concern with that. However, I had high standards with how I wanted to present the lab procedures. I first needed to make sure the lab would work and that I knew how to conduct the lab procedure, so I went through the experiment once without filming. Then, I needed to make sure I presented the procedure in a way that was clear and without any mistakes. Many shots took 3-4 tries as something would go wrong. Finally, there was an issue with my facility access. I wanted to make the lab procedure in advanced but couldn’t access the lab space until after the spring quarter ended. So I had to use my personal lab space, which often didn't have the same supplies/glassware that the students would be using, or it would take me a long time to find these supplies from other labs in the building. Overall, I would estimate that it took an entire Saturday (from around 8 am to 5 pm) of filming for one video. Then, compiling and editing took about 4 hours, making this a ~12 hour project to produce one video. Another issue was getting students to watch. I believe that students who were not familiar with GauchoCast may have been intimidated by the format and may have not found it easy to access during class. If I had shown them how to in advanced, that may have helped. If I had made watching the video mandatory, more students may have benefited, although I would have had to gauge how useful the students found the video.

One useful feature of GauchoCast is the ability to see who viewed the video and how long they viewed the video. 20 unique viewers (out of 24 students) looked at the video; five of those viewers used GauchoSpace to log-in to watch. More than half the views (11/20) stopped watching before the halfway point of the video (23 minutes long). Only 6 viewers watched >20 minutes of the video. GauchoCast also allows me to see when students viewed the video. The intention was for users to watch the video in advanced, which most students did, but to also watch it during lab. Just 1 viewer watched during lab. This may be that watching the video in advanced helped other students, but I did not feel unburdened with procedural questions from the students in the lab. I hope it did help some students with confidence though, since research suggests that students who are new to laboratory settings might feel anxious (Loonat, 1996). Videos might helped students be more prepared and might cut down on time that TAs need to spend answering questions, but I may have needed to make it mandatory for students to watch and/or made the video shorter (Gallardo-Williams et al., 2016). Even with the time spent making the video, I would do it again, but with a few recommendations: 1) require the students to answer procedural questions on a quiz/homework to ensure they understand the procedure; 2) omit mundane procedures like weighing out samples or mixing solutions in the video tutorial; 3) only make a video for a lab that will be repeated in the future to make it more worth it; and 4) obtain access to the correct facilities in advanced so that it is easier to perform the procedure.

Overall, I found that the intentional and deliberate use of technology in the classroom was beneficial. If not to keep the students engaged, it helped me prepare the class logically and in an organized way. I really enjoyed using Socrative and found it very beneficial, helping me increase student involvement in the lecture. I found that breaking up the lecture, especially with technologically-relevant tools, made my lectures fluid and organized and may have helped students who are more easily distracted. A video lab procedure may not be entirely necessary for most labs, as I learned, but could benefit for labs that are often repeated and are more complicated.

Requirement #4: Teaching your own course

The Science and Engineering Research Academy might be thought as a new teacher's dream; it provides the chance to design and teach your own course to a studious group of overachieving high school students; to experiment with teaching styles and topics; and to project my passion for any subject of my choosing. I had four weeks of lecture and lab to teach whatever topic (polymers) in science and engineering research that I wanted (see **Appendix 6** for syllabus.) It was an incredible opportunity to learn about course design and teaching, while improving my teaching skills. In line with my teaching philosophy, when designing this course, I set a few course goals: 1) Engage the students during lecture by asking questions intentionally; 2) Project an enthusiasm for the subject at hand; and 3) Incorporate technology in my classroom (discussed in Requirement #3, above). The course was a learning opportunity; I struggled through difficult challenges like time management and the whirlwind that was the first week of class and even through smaller trials that might be overlooked like narrowing down one or two key resources to base my class on. Through lessons learned while teaching the course, I now can think ahead to classes that I would design and teach in the future and understand how I would plan those differently.

An important takeaway from my experience teaching the course was how I set course goals, which helped me focus when planning lessons and allows me to grow as an instructor. First, I knew I wanted to engage students more during lecture by asking questions and encouraging discussion intentionally. As a teaching assistant, I found it difficult to improvise questions in class, which as a student, I thought was what instructors did. Another issue is my hearing impairment. I acknowledge that I'm self-conscious in class; therefore, I might come to a point where I find it pertinent to ask a question but would avoid asking the question or waiting for students to respond so that I don't have to struggle with hearing them. I avoided these two issues by intentionally planning questions to be asked when preparing lecture and by utilizing non-verbal personal responses (e.g., show of hands or Socrative). Students were, naturally, sympathetic when I couldn't hear. I found that over time, I knew which students I could hear better and could rely on those students to "translate" for me when a softer-spoken student was answering. I experimented with other ways students could ask questions, like providing notecards, but students did not fill these out. By planning specific questions and non-verbal ways for students to answer those questions, I could make students actively participate during the lecture. The other course goal to be discussed relates to projecting enthusiasm. In my former ESCI reviews as a teaching assistant, I was disappointed that I was rated fairly low for enthusiasm but understood why students might have thought that; I found it difficult to project my enthusiasm. I thought about this a lot and tried to deliberately shake any inhibitions that I might have had to being enthusiastic. I channeled instructors of the past who sang songs or made funny voices and used that to keep the students engaged. Just about every day, I shared news articles about polymer science and engineering research and did so with excitement. I was happy that all students (24/24) agreed or strongly agreed (average score of 4.8±0.3 for both answers with 5,4,3,2,1 being strongly agree, agree, neutral, disagree, and strongly disagree) that I had displayed enthusiasm for teaching and enthusiasm for science and for teaching (two separate questions; see **Appendix 7**). In the future, this will give me confidence to be a little crazy about the topic that I'm teaching, so that I can be an inspiration to students who might wonder why I'm so excited about such a narrow aspect of science and engineering.

As with my teaching philosophy, I learned a lot while teaching, especially in unexpected ways. I thought that beginning course planning in October (8 months before the course started) would help, but it felt a much smaller help than I thought it would be. There were goals I set to finish planning (e.g., lesson plans) months in advanced; I'm almost glad that I wasn't able to finish them. I had four lesson plans ready by the time the course started, which should have covered the first week. Those lesson plans ended up stretching out for the first two weeks or so. This was obviously not lost on the students, who rated my ability to present clear course objectives in the ESCI reviews as 1.7 (between "Excellent" and "Very Good") but rated the achievement of those goals as less favorable (2.0) with multiple students writing specific comments about our inability to progress quickly enough through the course. But in line with my teaching philosophy, I wanted to challenge students while not leaving others behind so I tried to balance that. Plus, I needed the extra time to not have to worry about speeding through lecture, especially given the difficulty of planning labs. I fell behind quickly with labs; I wanted labs to be customized for my class and pulled from a variety of sources, even designing my own labs for the students. I wanted the students to be successful so I did most of the experiments in advanced, but unfortunately, I couldn't keep up with the course. For example, I purchased samples of plastic for the students to learn about recycling, but the plastic came in thick sheets that had to be cut with an electric saw. After a normal day of work, I came back to lab in the evening and spent 3-4 hours dicing the sheets of plastic. That meant that I had no time left to try the experiment myself, especially since I needed to still review my lecture notes. Some experiments failed and some were not up to the standards that I wanted them to be, since I didn't get to try them out and adjust them beforehand. Of course, I always tried to make sure students were learning new lab skills or scientific concepts when experiments would fail (plus, failing is an important part of the process of research). However, I placed undue stress on myself by burdening myself with lessons and labs. It was surprising how difficult it was to balance both of these, and I was thankful that I had a TA to help. My struggles to keep up might be reflected in my ESCI reviews, which for my overall evaluation was lower than I would liked. My quality of teaching score was a mean of 1.8, which is between “Very Good” and “Excellent” but was lower than my peers and past evaluations. Multiple students mentioned preparedness and structure in lab as a problem in the course. The ESCI review also asked about my preparation and clarity, and I scored a 1.9, again worse than the mean of my peers (1.6). In the future, I would refer to more established sources of laboratory procedures rather than trying to design my own. It might be easier to design one or the other but having to do both lecture and lab was challenging.

Another surprise related to smaller aspects of teaching, like just choosing a way to teach a specific topic. This might have hindered my ability to plan the course even though I started in October. I would find multiple ways authors of books or lecturers on the internet would present a topic and make notes or bookmark a page to refer to it. In the end, I had four sets of notes; a few dozen internet resources; and two textbooks that all had similar information. By the time the course start date was approaching, I realized I needed to choose just one source for each topic and use that. Of course, it probably helped that I had background information from a variety of sources, especially when I explained to students who struggled, but it wasn’t particularly beneficial for my planning. In the future, I would hone in on topics that I wanted to teach, then find one specific resource to plan then lesson. Then, after the lesson is planned, I might find other resources that could help with insight and understanding.

I tried two other experiments in the course that didn’t really relate to any course goals but were important to me in understanding how to properly evaluate students’ progress and how to hold students accountable. For the first three weeks of class, I gave students a daily quiz (example **Appendix 8**) that related to topics that students learned that day in lecture. I also included one question that asked students what the most confusing topic to them was and what they thought their peers found most confusing. As an aside, I found these last two questions very important in planning my next lecture and often was able to spend about five minutes clarifying confusing points. To the point, the quiz was a careful balance between student stress and instructor feedback. I understood that some students would be obsessed with their grade and might worry about the quizzes, so I told students that the grades would be shifted so that the average quiz scores would be a B+. I also wanted to encourage class participation so I included 1-2 questions that were identical or similar to Socrative questions in class. Then I wanted to challenge students so I included some conceptual questions that went beyond what we might have learned in class. Many students never scored a perfect grade on a quiz; some quizzes had to be scaled with the average. This was good because I was challenging students. I heard from the program director that some students were shocked that I was giving out quizzes; they had always heard of quizzes as an empty threat to make students pay attention. So I wanted to know if students were anxious about the quiz. In the supplemental course review, I asked students if they remembered a specific time they were anxious before taking a quiz. Most students felt neutral, but 8/24 students agreed that they felt anxious. No students left specific remarks about quizzes in the comments of the ESCI reviews. During the course, I voiced some of my concerns to one student, who had struggled on some of the quizzes and course material. She had mentioned that the quizzes were hard, and that she liked to go over her lecture notes at home a second time before she felt she fully understood the material. I asked her what she thought of the quizzes and she said that most students shouldn't be worried because they signed up for the class and knew it would be difficult. I think that is a good attitude to have but acknowledge that not all students might think that way. In the future, I might rephrase the evaluation so there isn't the stressful connotation associated with the word quiz or change when I introduce the evaluation. In addition to a quiz, I also had an open-book midterm. I found this to be an effective way to evaluate how I was teaching and saw some holes in students' understanding of important topics. In the past, I've shied away from tests and formal evaluations, but I found that they were useful in helping me understand where students are in their learning. The second experiment that I tried was to let students choose their own grade for participation. I thought this was a good idea since they would be accountable for participating. Reflecting on it, it might seem cruel and manipulative, like abusive punishment in the past that would make children choose what implement they wanted to be hit with, in that students had to justify their grade. However, I hope the students didn't see it that way. I didn't find it to be beneficial; I probably would have given most students top scores for participation except for egregious cases, but more students were critical of themselves that I was. I would avoid something like this in the future. Again though, no students mentioned this method of grading in the course evaluations.

Requirement #4-1: ESCI Reflection

Looking more analytically at my ESCI reviews, I can glean some ways that I can improve a future iteration of this course or of a similar course (along with the improvements that were mentioned earlier in this section). At first glance (**Appendix 9**), I note that none of my scores (lower being better) were better than my peers for this quarter (sample size = 96). Against peers and campus-wide all-time (which only includes last year, as that was the first year), I faired a little better. All scores were better or the same against SERA instructors all-time, although the median for my overall quality of teaching was lower (achieving Very Good vs. Excellent). My overall quality of teaching and the course absent of teaching were the same or better compared with other SERA courses that include last year's sessions, which is something that I should strive to improve most of all. The course absent of teaching typically reflects the departments planning and training, but in this case, I prepared the course myself so it is a direct reflection of my own work. As discussed before, I can look at the scores on my objectives and note that I need to consider time management when designing the course. It might be better to plan too much but not stress the students with thinking they need to learn that much. The differences in the scores may not be significant given how close they are to my peers and across the campus all-time; however, I strive to improve my teaching and wish the scores to be better. Doing so will require more experience teaching, using the lessons I learned from this course to improve my quality of teaching and the quality of my course.

The supplemental course review also provides quantitative data on how the course fared and was perceived by students (**Appendix 7**). Most of this document was discussed in the technology section of this portfolio. However, some questions have yet to be considered: one question that I asked in two ways was how fast or slow the course went. I first asked if students agreed with whether the course was too slow, then later asked if students thought the instructor went too fast. In both cases, students mostly disagreed that I went too fast and were consistent in their answering, also mostly agreeing or feeling neutral that the course was too slow. This is one thing to think about; in my teaching philosophy, I mention that I wanted to challenge students but not leave students behind. I err on the slow side, but might be losing students' interest. In the future, it will be useful to find a balance; to find ways to identify those who are bored and specifically challenge them with extra discussion questions or with an opportunity to teach the class what they know about certain topics.

More instructive might be specific comments in the ESCI evaluations. I have taken to heart some of the suggestions; some students identified and confirmed the concerns I had that the lab was sometimes disorganized. Others noted inconsistencies in my teaching, that I was sometimes unclear but sometimes very good. Some suggested that some of my attempts to be clear actually make things confusing; they mentioned that I avoided challenging terms/concepts. I intentionally avoided what I considered "definition terms" that are memorized in certain areas of science since the students were from different grade levels and didn't necessarily have the same background in chemistry or physics. However, I think this might have confused some students who were very familiar with those terms and didn't like how I used what I thought would be simpler/more intuitive to understand (e.g., discussing "non-bonding interactions" vs. "Van der Waals forces", which would be more familiar to students who had taken chemistry). I acknowledge that this could be confusing, and I should have just taken the extra time to define some (but maybe not all) of these sort of terms. Some students complained about the structure of the course, that it was lacking, and that I think comes with experience. I now understand a little bit of what it's like to design and teach my own course; next time, I can focus more on the structure and order.

Requirement #5: Reflection of CCUT Portfolio Preparation

In compiling and writing this portfolio, I was surprised how much I enjoyed reflecting on teaching. It really confirms, to me, my desire to teach. I was also surprised with what I learned fulfilling each requirement. In writing Requirement 1, I relived memories that I hadn't thought about in years, by referring to a blog that I had written during that time. I also was able to think critically about what the ESCI evaluations meant to me, and how I could use those evaluations to improve my teaching. When I first received those scores, I might have brushed them aside or not thought too deeply about them. But sitting down, intentionally evaluating myself, can lead to growth and development as an instructor. For Requirement 2, again, I was happy to think fondly of a wonderful teaching experience that I had in the School for Scientific Thought. I was able to see, now, some naivety that I had about teaching, but also how I had developed from my first teaching experiences. Again, there was much room for improvement. In looking back on Requirement 3, which wasn't too long before writing this portfolio, I was able to see how intentionally trying to incorporate something new challenges me as an instructor, throwing a wrench into my typical gears and forcing me to change. This challenge opens my eyes to new possibilities, forcing me to consider novel ways of teaching and teaching me new opportunities to help my students in their education. When writing Requirement 4, I decompressed a stressful time and picked apart the weights that bore on me the most. I have clear, concrete ways to continue to improve.

It seems like the most important thing that I learned, consistent with my teaching philosophy, is how much I don't know. Before teaching my course as the instructor of record, I could look at my first TA experiences and think of all the things I did wrong: not learning students' names; not asking students questions in class; not preparing enough in advanced, etc. But even now, looking back as instructor of record, I still see mistakes: mostly, in this case, poor time management and a bit of disorganization. But fortunately, I also see improvement. I knew all the students names. I asked questions. I tried new things as a teacher that I hope helped my students learn better. I can see that as I continue to teach, then reflect and evaluate, then reconsider my teaching strategies, I can continue to improve. I hope to do so. I want to continue to teach, and I want to continue to learn.

Appendix

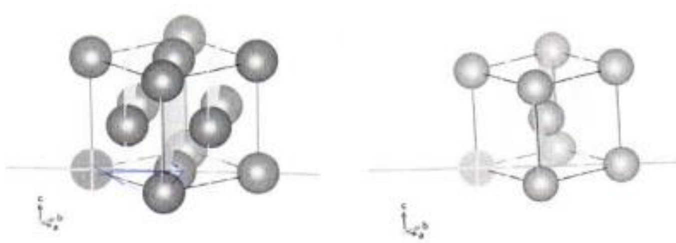
Appendix 1: PSET 1 and PSET 2 samples to compare changes in preparedness

PSET 1 [redacted]

1. **Crystal Structures**

a) Sketch a single unit cell each for the face-centered cubic (FCC) crystal structure and for the body-centered cubic (BCC) crystal structure. For both structures, sketch the [110] crystal direction and two lattice planes normal to the crystal direction. Identify your planes using conventional nomenclature. Difference in notation

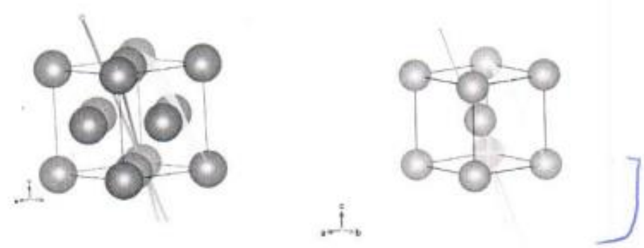
Solution: The (110) and (220) lattice planes are pictured below. There are multiple correct answers (e.q. (660) (440) etc.)—full points will be awarded as long as the lattice planes are normal to the vector and contain only integers.



[ ] →
{ } →
( ) →
< > →

b) Sketch the FCC and BCC unit cells along with the [213] and [111] crystal directions on each. Be sure to indicate your axes. Next, identify and sketch a corresponding lattice plane that contains both directions. Find the components of the [213] and [111] families of directions that are also contained in this plane.

Solution:

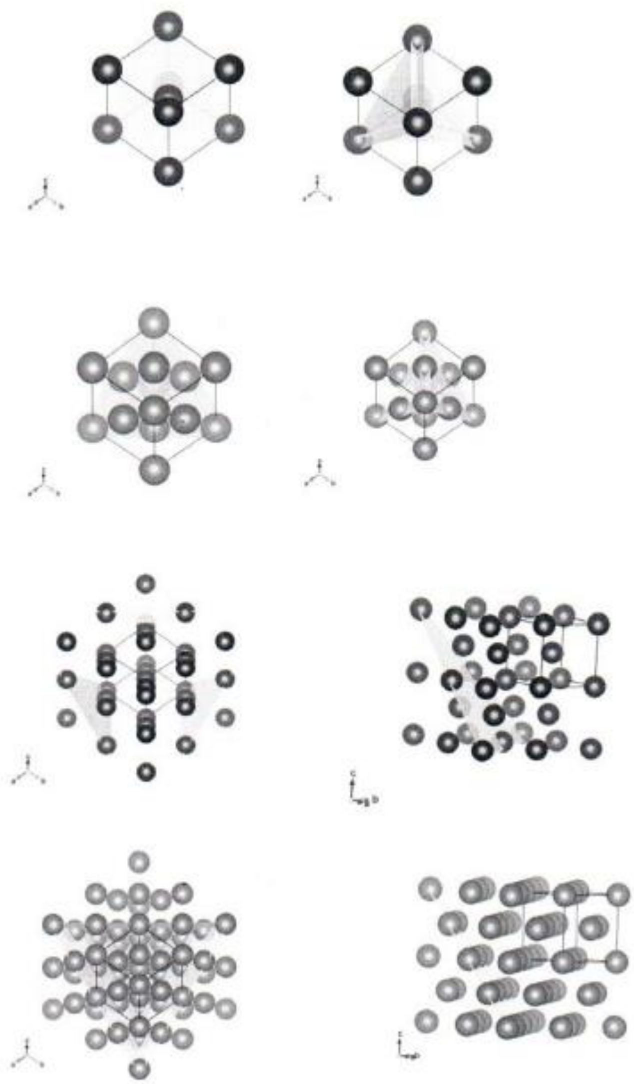


given

The corresponding lattice plane is (-211) which is found by taking the cross product between [213] and [111] and realizing that the resulting crystal direction is normal to both the given directions and to the (-211) plane. Hence (-211) is parallel to the given directions. When the dot product between a certain vector and [-211] is zero, the direction is contained in (-211) plane. Hence, [213], [231], [111], [-1-1-1] [2-1-3]

[-2-1-3] [-2-3-1] and [2-3-1] are all included in the plane.

c) Draw the family of {111} lattice planes for both FCC and BCC structures. Be sure to indicate the directions of your coordinate system. (Hint: when needed, redefine the location of the origin to simplify your drawings)



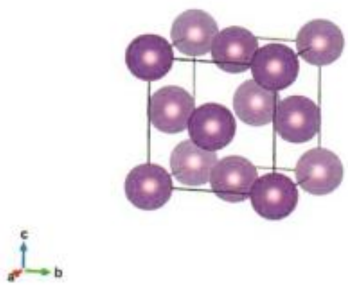
MATERIALS 101 **INTRODUCTION TO STRUCTURE AND PROPERTIES** **WINTER 2014**

PS 2
Due: January 28th, 2014

1. Anisotropy in Crystal Structures

a) Explain how a polycrystalline material, composed of anisotropic grains, can behave isotropically. anisotropic grains → directionality of properties
isotropic → properties are independent of direction of measurement
crystallographic domains are completely random. Basically the average of all grains dictate the magnitude of a measured property. If all grains are random, averages cancel each other out.

b) Consider the FCC unit cell structure below. Calculate the planar packing factor (i.e. [area of atoms per plane]/[area of plane within the unit cell]) for the (001), (011) and (111) lattice planes. Identify the plane with the highest planar packing factor.

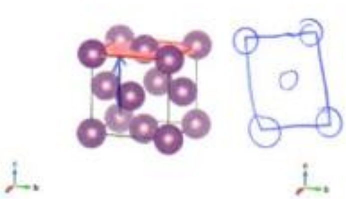


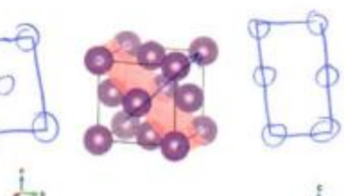
How does a relate to r in FCC? $4r = \sqrt{2}a$

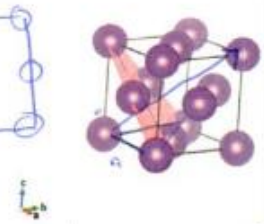
$r = \frac{\sqrt{2}}{4}a$

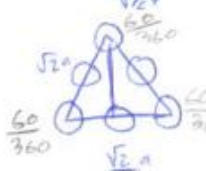
$\left(\frac{2\sqrt{2}a}{2}\right)^2 - \left(\frac{\sqrt{2}a}{2}\right)^2 = h^2$

$h = \frac{\sqrt{3}}{\sqrt{2}}a$









area of plane = a^2

area atoms occupy = $4 \cdot \frac{1}{4} \cdot \pi r^2 + \pi r^2 = 2\pi r^2$

$= \frac{2\pi}{8}a^2 = \frac{\pi}{4}a^2$

$PPF = \frac{\pi}{4}$ for FCC 0.785

area of plane = $\sqrt{2}\,a^2$

area atoms occupy $4 \cdot \frac{1}{4}\pi r^2 + 2 \cdot \frac{1}{2}\pi r^2 = 2\pi r^2 = 2\pi\left(\frac{1}{8}a^2\right)$

$PPF = \frac{\pi}{4\sqrt{2}}$

0.555

area of plane $\sqrt{2}a \cdot \frac{\sqrt{6}}{2}a$

area atoms occupy: $3 \cdot \frac{1}{3}\pi r^2 + 3 \cdot \frac{1}{2}\pi r^2 = \frac{5}{2}\pi r^2$

c) Using a simplified bond density argument, explain the following trend (Table 3.3 *Callister*) in the modulus of elasticity in terms of your answer to 'b'.

"slip" occurs on most densely packed crystallographic planes

Table 3.3 Modulus of Elasticity Values for Several Metals at Various Crystallographic Orientations stiffness

	Modulus of Elasticity (GPa)		
Metal	*[100]*	*[110]*	*[111]*
Aluminum	63.7	72.6	76.1
Copper	66.7	130.3	191.1
Iron	125.0	210.5	272.7

111 has higher PPF so has higher modulus of elasticity.

001 has lower PPF but bond distance are greater (weaker bond energy)

110 is next lowest

As planar density ↑, # of nearest atoms in plane ↑, # of "satisfied" atomic bonds" ↑, # of "unsatisfied" atomic bonds ↓, surface energy ↓

d) Hard disk drives utilize a magnetic storage material to store bits of data. Explain how magnetic anisotropy plays a role in the orientation of the magnetically active material (see the discussion in section 20.11 of Callister). Particulate media

- Particle alignment in parallel
- magnetic moment lies along axis
- stores information in two ways → 1s or 0s (~~top or bottom~~)

reversed, large # of atoms

Thin Film → newer, higher storage capacity
- each grain within film has magnetic domain (greater packing efficiency)

2. Polymers

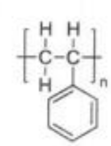
a) Identify the following polymers based on their structures, draw the unreacted monomer(s) for each, and give an application for each polymer.

i.

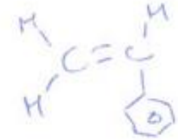
Teflon → polytetrafluoroethylene

nonstick coating

ii.



polystyrene used in rubbers



Appendix 2: Prelabs provided by the chemistry department and my own re-written for a clearer chalkboard

Experiment 5 Molar Volume of a Gas

ask students ; What is the objective of this experiment?

1) Determine molar volume of $O_2\,(g)$ at experimental T and P

2) Determine molar volume of $O_2\,(g)$ at STP

what is STP ? 1 atm , 0 °C

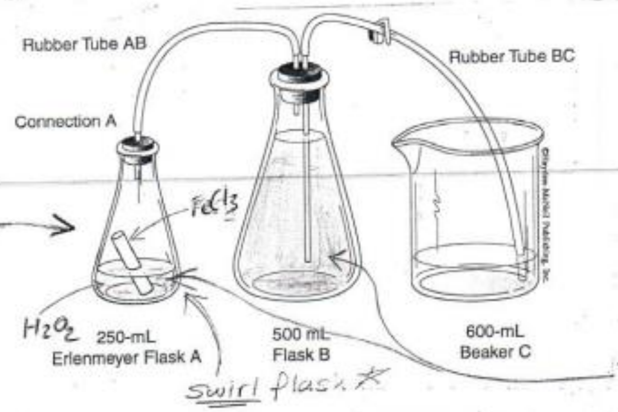
How do we determine the molar volume of O_2 ?

molar volume units? $\frac{L}{mol}$ ← measure $V_{O_2(g)}$; ← determine moles $O_2\,(g)$

How do we measure the volume of $O_2\,(g)$?

by water displacement

swirl flask →



$T_{O_2(g)} = T_{soln}$

T_{soln} = average Temperature of soln in flask A and flask B.

Figure 1. Note the position of the clamp, it is near the top of flask B.

reaction ? $H_2O_2 \rightarrow$?

$$2H_2O_2\,(aq) \xrightarrow[\text{catalyst}]{FeCl_3} 2H_2O\,(l) + O_2\,(g)$$

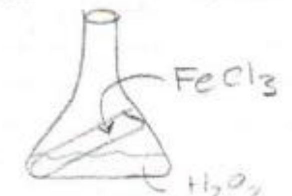
molar volume $\frac{L}{mol}$ ← $V_{O_2(g)}$

← determine moles O_2

how?

from missing mass

weigh flask + reactants



students must complete all calculations in lab ← TA initials required

1) weigh before rxn
2) weigh after rxn

$O_2(g)$ escapes during rxn

missing mass = mass of O_2

mass O_2 $\xrightarrow{\text{molar mass}}$ moles O_2

1) Calculate molar volume at experimental T, P
L/mol

2) Determine molar volume at STP (0°C, 1atm)

Initial (from Exp)	Final (STP)
	V_2 = ?
V_{O_2} =	P_2 = 1atm
P_{O_2} =	T_2 = 273K
T_{O_2} =	

temperature of O_2 = temperature of solutions (A, B)

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \qquad V_2 = V_1\left(\frac{P_1}{P_2}\right)\left(\frac{T_2}{T_1}\right)$$

$V_2 = V_{O_2}$ at STP

molar volume = $\frac{V_{O_2}(STP)}{n_{O_2}}$ compare with 22.4 L/mol

Week of 02/10/13 Molar volume of Gas

1) Determine molar volume of O_2 at experimental T & P
2) Determine molar volume of O_2 at STP ? ← what is STP? 0°C, 1atm

what is molar volume? units?

L ← measure V_{O_2}

mol ← measure mass

V_{O_2} harder!
water displacement

$$2H_2O_2(aq) \xrightarrow{FeCl_3} 2H_2O(l) + O_2(g)$$

conservation of mass → weigh flask before, weigh flask after
use same scale!

1) Test tube check
2) ~~Leak check (pump w/ bulb~~
2) Remove air bubbles (bulb)
3) Check for leaks (move up and down, should stabilize)
   ↳ what do we mean by "leaks"?
   leak in corks?, adding pressure/letting pressure escape)
4) Equalize pressure ← empty beaker!
5) swirl reaction flask / cool soln in water bath
6) Let sit for ~15 min so temp A = temp B
7) Measure T_{soln} in A & B
8) measure vol of H_2O in beaker
   ↳ why? How?

P_{O_2} = P_{STP} =
V_{O_2} = V_{STP} =
T_{O_2} = T_{STP} =
n = n_{STP} =

Appendix 3: Figures for ESCI reflection

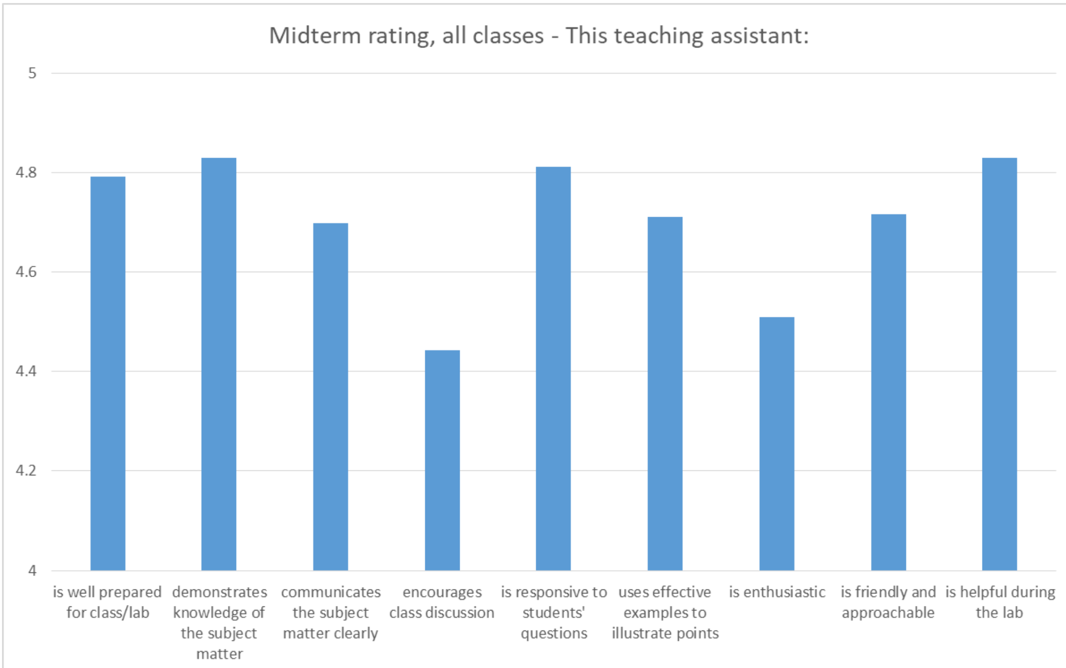


Figure 1. Bar graph of midterm ratings; note the scale bar from 4-5, where 5 is the most favorable adjusted rating and 1 is the least favorable. 53 respondents in three classes participated.

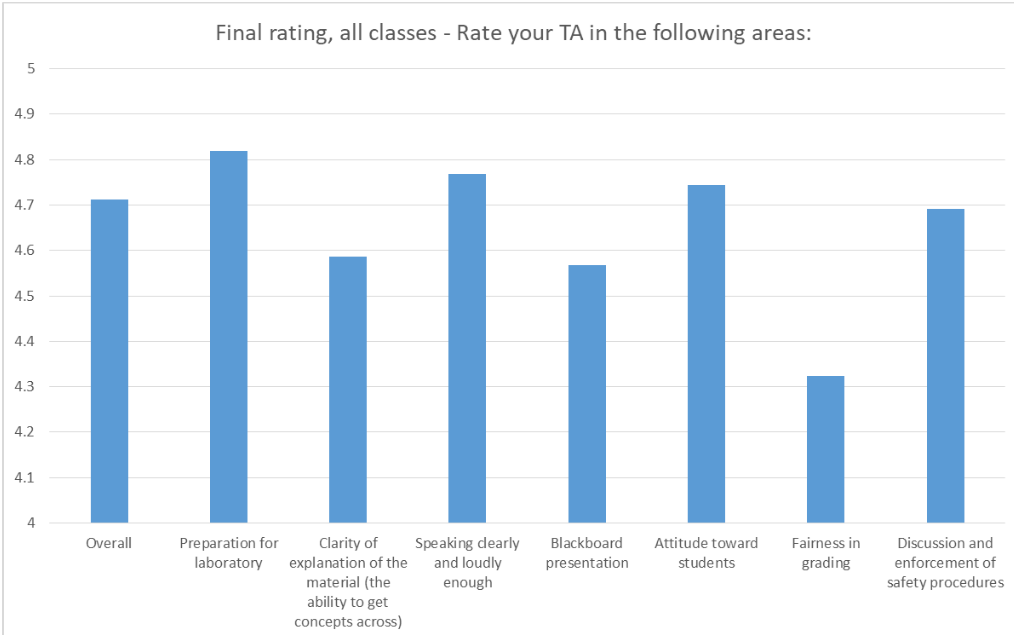


Figure 2. Bar graph of final ratings; note the scale bar from 4-5, where 5 is the most favorable adjusted rating and 1 is the least favorable. Also take note not to directly compare Figure 1 and Figure 2. Questions being asked are not the same. 66 respondents in three classes participated.

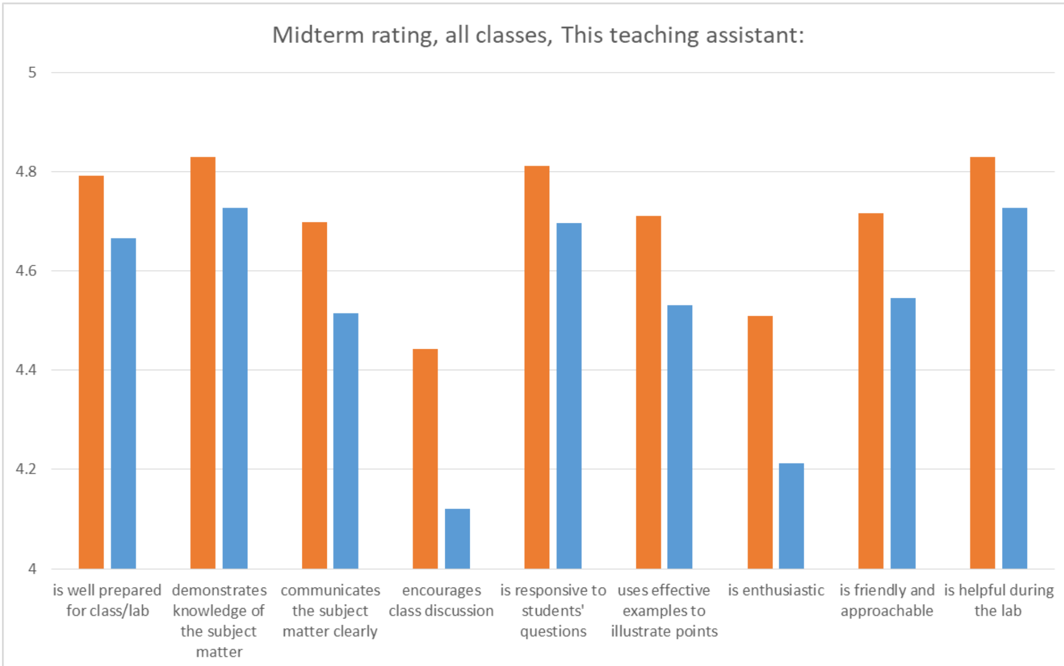


Figure 3. Bar graph of midterm ratings; note the scale bar from 4-5, where 5 is the most favorable adjusted rating and 1 is the least favorable. Orange represents midterm ratings with perfect scores included, i.e., those students who rated the TA as perfect 5's for all categories (as shown in Figure 1.) Blue represents midterm ratings without perfect scores included. 33 respondents in three classes participated.

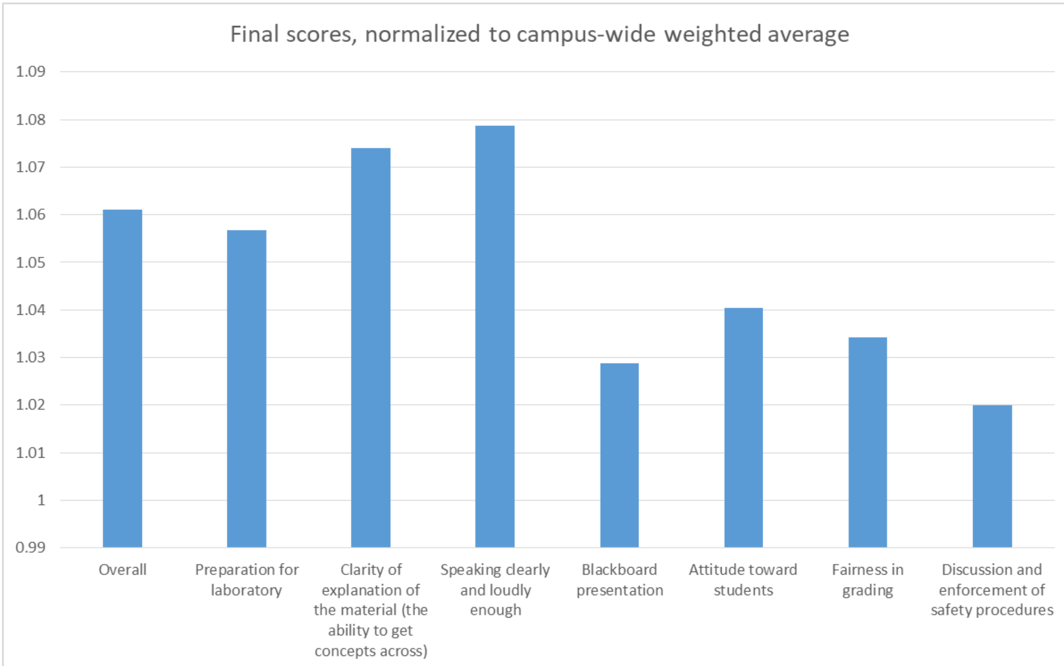


Figure 4. Bar graph of final scores normalized to campus-wide all TAs over time. A score > 1 indicates that the TA ratings were higher than the campus-wide ratings.

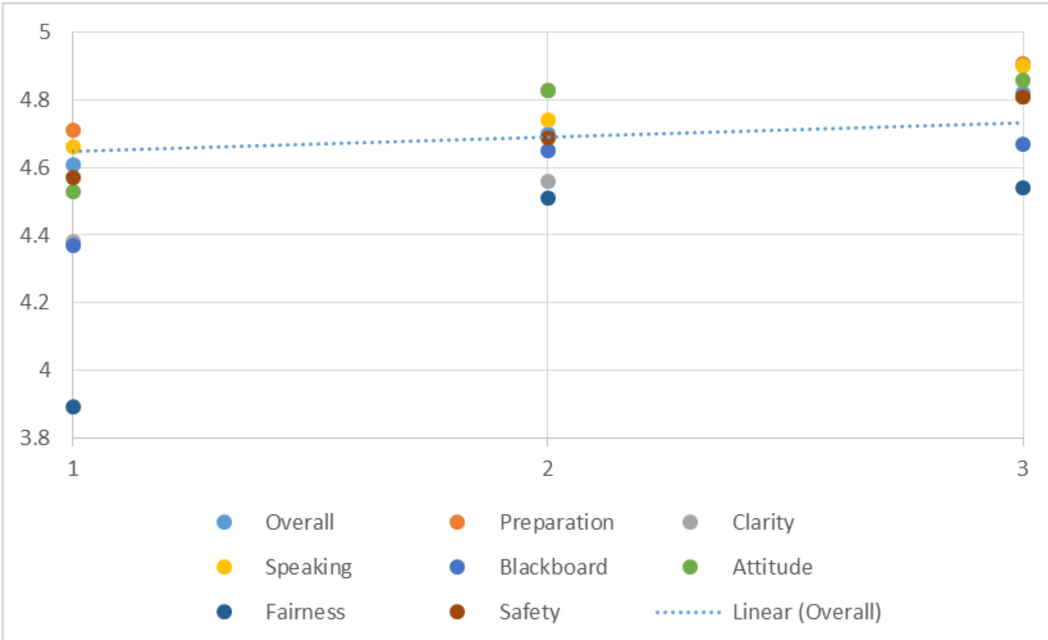


Figure 5. Upward increasing trend of scores (y-axis) over different days (x-axis where day 1 = Tuesday afternoon section, 21 responses; day 2 = Wednesday evening section, 23 responses; and day 3 = Friday evening section, 22 responses). The trend line shows the relationship of my overall rating over each day. 5 is the most favorable adjusted rating and 1 is the least favorable

Figure 6. Word cloud of comments for final feedback for strengths (left, checkmark) and weaknesses (right, x). Common usage words were omitted. Larger words indicates higher frequency of usage.

Appendix 4: Surveys for midterm and final student feedback

Course: Chem 1AL TA's name: Michael Ford.

EARLY FEEDBACK FORM

Dear Student: Thank you for taking the time to fill out this confidential questionnaire thoughtfully. The information will be used solely by your TA to see how to help you learn more.

Please rate the following on a scale of five (strongly agree) to one (strongly disagree). NA = not applicable.

This teaching assistant:	SA	A	N	D	SD	
1. is well prepared for class/lab	(5)	4	3	2	1	NA
2. demonstrates knowledge of the subject matter	(5)	4	3	2	1	NA
3. communicates the subject matter clearly	(5)	4	3	2	1	NA
4. encourages class discussion	(5)	4	3	2	1	NA
5. is responsive to students' questions	(5)	4	3	2	1	NA
6. uses effective examples to illustrate points	(5)	4	3	2	1	NA
7. is enthusiastic	5	(4)	3	2	1	NA
8. is friendly and approachable	5	(4)	3	2	1	NA
9. is helpful during the lab	(5)	4	3	2	1	NA

Course Assessment Questions:

10. What are the two greatest strengths of the teaching methods used by the TA and why are they strengths?

He actively demonstrates and how to set up the apparatus.
He's good at explaining why we're doing something.

11. What improvements could the TA make in this class and in his or her teaching to help you learn more? Suggest how these improvements could be made.

Make the lesson part of the class shorter so we can have more ~~to~~ time to work on lab.

TEACHING ASSISTANT EVALUATION—LOWER DIVISION
DEPARTMENT OF CHEMISTRY AND BIOCHEMISTRY, UCSB

Teaching Assistant: Michael Ford Course: Chem 1AL Quarter: Winter Year: 2015

The Department of Chemistry and Biochemistry is interested in your evaluation of our Teaching Assistants, and we would appreciate your completing this brief questionnaire. Your comments will be very useful to the department in helping us to upgrade our standards of teaching at all levels.

Please rate various aspects of your teaching assistant's efforts on a scale from "excellent" to "very poor," and mark your responses with a soft lead pencil in the appropriate places on the accompanying form. We encourage you to also make more detailed comments in the spaces provide because these provide us with the most detailed information.

(a) excellent (b) good (c) satisfactory (d) poor (e) very poor

1. Overall rating of your TA as a teacher? A

Rate your Teaching Assistant in the following areas:
2. Preparation for laboratory
3. Clarity of explanation of the material (the ability to get concepts across)
4. Speaking clearly and loudly enough
5. Blackboard presentation
6. Attitude toward students
7. Fairness in grading
8. Discussion and enforcement of safety procedures

Please answer the following directly below the question in the spaces provided:

A. What do you feel is our TA's strongest attribute?

Blackboard presentation of lab procedure is really helpful.

B. What do you feel is your TA's weakest point?

The following questions pertain to the laboratory *only*, not your teaching assistant:
9. What was the condition of laboratory (chemicals, cleanliness, benches, etc.)? good
10. What was the condition of your lab drawer/box? good.
11. Please rate the storeroom service A

12. How interesting were the experiments? A
13. How long did it take you to write your reports (on average)?
(a) <1 hour (b) 1 hour **(c)** 2-3 hours (d) 4-5 hours (e) >5 hours

Comments on the laboratory itself:

Appendix 5: Lesson plan incorporating Bloom's taxonomy

Lecture 2 – Bonding & Molecules in 2D, working in a laboratory, final project topics

Course time and date: 9:30 – 10:50 AM PHELP 2536

I. Learning objectives

By the end of this lecture, students will be able to:

a. Identify different types of bonding
b. Relate material properties to the types of bonding that comprise the material
c. Define the types of bonding that are relevant for polymers
d. Extend class discussion to identify polymers based on their drawn structure
e. Understand the hazards and etiquette of working in a laboratory
f. Select a final project topic

II. Bridge-in

To catch the interest of the students in this lesson, I will:

a. Bring in different materials that have different bonding properties
    a. https://www.youtube.com/watch?v=ODnqtf3aAvw
b. Use the gecko lizard example as an example of types of bonding observed
c. Surface tension demo with water vs . oil
    a. https://www.youtube.com/watch?v=rI-2wPluNqA

III. Teaching content

The specific topics that the students will learn are:

a. Ionic, covalent, and metallic bonding
b. Electronegativity/electron affinity
c. How to draw bonds and molecules
d. Van der waals forces, London dispersion forces, and hydrogen bonding
e. Bond strength and properties
f. Bonding in polymers
g. Lab safety summary/how to keep a clean lab
h. Benefits for each possible research topic

IV. Learning activities

The learning objectives will be met by:

1. Chalkboard/PowerPoint/Materials discussion on the different types of bonding, including gecko lizard (20 minutes)

2. YouTube video and discussion on electronegativity (5 minutes) https://www.khanacademy.org/science/biology/chemistry--of-life/chemical-bonds-and-reactions/v/electronegativity-trends
3. Chalkboard introduction to drawing chemical structures + challenge for students to draw on their own (15 minutes)
4. PowerPoint on intermolecular forces (10 minutes)
5. Hydrogen bonding demo (5 minutes)
6. In-person examples/video examples of how bond strength impacts properties (10 minutes)
7. PowerPoint presentation of different final project choices (10 minutes)
8. Final quiz (5 minutes)

V. Assessment

I will know the students have met the learning objectives by:

a. Asking questions to test understanding (need specific questions still)
b. Giving a quick quiz at the end with questions for each learning goal
c. Assigning, including reworded quiz questions in homework

VI. Relate to summative evaluation

I will have feedback on my lesson by:

a. Including a question on the quiz about how fast or slow the lesson went
b. Compare quiz and homework questions to see how students progressed after lecture vs. on their own
c. Ask individuals about their progress in lab/discussion

Appendix 6: Syllabus from instructor of record course (SERA program)

Track 1: Plastic Fantastic

Course: SERA Track 1: Plastic Fantastic

Instructor: Michael Ford
PSBN 2520C
mjford@umail.ucsb.edu
Office hours: Friday, 1:00-2:00 PM, PSBN 2520D

Teaching assistant: Abigail Serrano
Office hours: TBD

Text: None required – reading material provided as needed
University of Cambridge Teaching & Learning Packages
Polymer Chemistry by David Teegarden
Giant Molecules by Alexander Grosberg and Alexei R. Khokhlov

Website: https://gauchospace.ucsb.edu

Course description:

In this course, we'll dive into current topics of polymer research. We will focus on specific research endeavors that companies and universities are undertaking. We will connect scientific or engineering concepts with work that local start-up companies and academic research labs are pursuing. The course will consist of four weeks of lecture, two weeks of laboratory, and two weeks of research. While much of the course will focus on basic concepts of polymer science and engineering, the students will also learn valuable skills that can be applied across all scientific disciplines, like how to develop a research question; how to perform original research; and how to present research.

Course goals:

By the end of this course, students will have learned various aspects of polymer science/engineering and science/engineering research in general.

Polymer science & engineering goals:

- Define what polymers are and why they are a unique class of materials
- Recognize how polymer structure relates to polymer properties
- Implement understanding of polymer science and engineering in a lab/real life setting
- Compare/contrast properties of different classes of polymers
- Evaluate data related to polymer science
- Design experiments to investigate how polymer structure impacts properties

Science & engineering research goals:

- State the difference between academic and industrial research
- Identify good questions to ask during a scientific talk
- Use general skills learned in laboratory
- Organize a research talk/paper/proposal
- Critique data that supports/refutes a hypothesis
- Develop a research question

Grading:

Attendance: 10%
Quizzes & Exam: 20%
Homework: 15%
Lab reports: 15%
Final project: 40%

Attendance: Attendance to all lectures, all labs, and the final project presentations is mandatory. Exceptions granted for health & well-being must be discussed over e-mail as soon as possible. Students will determine and justify their own attendance grade.

Quizzes & Exam: Daily quizzes will be assessed to test understanding and to provide feedback for instruction. Since the quizzes will be designed as a feedback tool, grades will be normalized to the average scores with an average score given a B+. A midterm assessment will be given based on quizzes, homework, and lab reports.

Homework: Homework will be assigned on each day that we have lecture. Homework questions will be related to the daily quizzes and will also include readings and videos that will help prepare for the next lecture or will help reflect on research.

Lab reports: Lab reports will either consist of worksheets (first week of class) and/or typed reports that will prepare students for the final project report. Lab reports are due at the end of the week. Pre-labs must be completed and signed by the instructor before each lab.

Final project: All students will be required to work in a group to craft an original research question and conduct original research. The final project will culminate in a presentation at the end of the SERA program. Further details will be given in class.

Academic Integrity: Academic dishonesty includes acts of cheating, plagiarism, and collusion. Individuals are responsible for upholding the University's standards for academic integrity. This includes, but is not limited to, copying the work of others, using ideas/content without proper citations, and assisting another student in cheating/plagiarizing. More information can be found at https://judicialaffairs.sa.ucsb.edu/AcademicIntegrity.aspx

Student Services: UCSB students have access to a wide range of services that will assist in issues of mental health and well-being and other issues you may encounter in your daily lives. Please take these issues seriously, and reach out if you need help. Find more information at http://oic.id.ucsb.edu/getting-started-ucsb/campus-services. Students who need assistance with accessibility in the classroom or on campus should visit http://dsp.sa.ucsb.edu/.

Sexual Harassment: "UCSB does not tolerate sexual harassment/sexual violence, which is prohibited by University policy and state and federal law. The Title IX Compliance and Sexual Harassment Policy Compliance Office (TIX/SHPC) provides assistance in preventing and resolving and investigating complaints of sexual harassment/sexual violence and gender discrimination." (https://oeosh.ucsb.edu/titleix/)

Lecture schedule (subject to change):

Week 1 –Bonding and polymer synthesis

06/25/18 – Syllabus, polymer history/classification, what to notice during a research presentation, final project topics introduction

06/26/18 – Bonding and molecules in 2D, working in a laboratory (safety, lab etiquette),
choosing final project topics

06/27/18 – Bonding and molecules in 2D, bonding and molecules in 3D, polymer models, thermal properties of polymers, how to formulate a research question

06/28/18 – Chemical reactions, polymer synthesis, how to write a research report

Week 2 – Size and structure

07/02/18 – Polymer synthesis, types of synthetic polymers, statistics in polymer science & engineering, how to present research

07/03/18 – Polymer sizes (chains) and models, statistics in polymer science & engineering, looking at graphs in research

07/04/18 - Holiday

07/05/18 – Polymer sizes (aggregates, microstructure), characterization techniques, peer review and how to read a research article

07/06/18 – Midterm exam

Week 3 – Topics of research in polymer science & engineering

07/10/18 – Apeel visit

07/11/18 – Soft robotics

07/12/18 – Polymer semiconductors/conductors

07/13/18 – Biodegradable polymers, green chemistry (Mango Materials visits UCSB)

Week 4 – Topics of research in polymer science & engineering

07/16/18 – Polymer lithography

07/17/18 – Polymers for displays (Light Polymers) and other synthetic polymers

07/18/18 – Miscellaneous polymer science & engineering research

07/19/18 – Course summary, advice for presentations, presentation practice

Lab schedule (subject to change):

Week 1

06/26/18 – Introduction to lab, polymer identification test

06/27/18 – Guided library research

06/28/18 – Silly Putty synthesis

Week 2

07/02/18 – Polymers for soft robotics

07/03/18 – Polymer lithography/conducting polymers

07/05/18 – Polymer thermodynamics (elastomers)

Week 3

07/10/18 – Biodegradable polymer properties

07/11/18 – Lab time for research projects

07/12/18 – Lab time for research projects

07/13/18 – Lab time for research projects (if necessary)

Week 4

07/17/18 – Presentation preparation (lab open if needed)

07/18/18 – Practice talks

07/19/18 – Practice talks

Appendix 7: Supplemental course review from instructor of record course

Supplemental course review **INT 93LS – Plastic Fantastic**

1. The pace of the course was too slow.

Strongly agree Agree Neutral Disagree Strongly disagree

2. I feel I learned well from lessons taught primarily on the white board.

Strongly agree Agree Neutral Disagree Strongly disagree

3. I feel I learned well from lessons taught on the doc-cam.

Strongly agree Agree Neutral Disagree Strongly disagree

4. I feel I learned well from lessons taught on PowerPoint.

Strongly agree Agree Neutral Disagree Strongly disagree

5. I remember a specific time that I was confused after a lesson taught on the white board.

Strongly agree Agree Neutral Disagree Strongly disagree

6. I remember a specific time that I was confused after a lesson taught the doc-cam.

Strongly agree Agree Neutral Disagree Strongly disagree

7. I remember a specific time that I was confused after a lesson taught on PowerPoint.

Strongly agree Agree Neutral Disagree Strongly disagree

8. I can remember a specific time that I was anxious before taking a quiz.

Strongly agree Agree Neutral Disagree Strongly disagree

9. I can remember a specific time where Socrative questions helped me on the quiz.

Strongly agree Agree Neutral Disagree Strongly disagree

10. I remember a specific time where taking the quiz helped me figure out the homework.

Strongly agree Agree Neutral Disagree Strongly disagree

11. The instructor went too fast throughout the course.

Strongly agree Agree Neutral Disagree Strongly disagree

12. The instructor’s handwriting made it challenging to learn sometimes.

Strongly agree Agree Neutral Disagree Strongly disagree

13. The instructor displayed enthusiasm about teaching in lecture and lab.

Strongly agree Agree Neutral Disagree Strongly disagree

14. The instructor displayed enthusiasm about science in lecture and lab.

Strongly agree Agree Neutral Disagree Strongly disagree

Appendix 8: Quiz example from instructor of record course

Quiz 5 Name:__________________

1. (2 pt) **True / False** : Monomers on a single polymer chain are bonded together by covalent bonds
   True / False : All polymers need hydrogen bonding to form solid structures.
   True / False : At the molecular level, atoms/molecules do not interact in a liquid.
   True / False : Each research group only needs to turn in one final report.

2. (2 pt) Give one example of a non-bonding interaction in polymers.

3. (3 pts) Draw schematically and show what properties of the chemical structure make Teflon (polytetrafluoroethylene, $[-CF_2-CF_2-]_n$) non-stick/chemically stable.

4. (2 pts) Van der Waals interactions use differences in electron density to form intermolecular bonds. If the molecule has little or no dipole, how are Van der Waals interactions formed?

5. (1 pt) What topic in class today was the most confusing for you? What topic do you think your peers had the most trouble understanding? (No wrong answers!)

Appendix 9: ESCI evaluations for instructor of record course

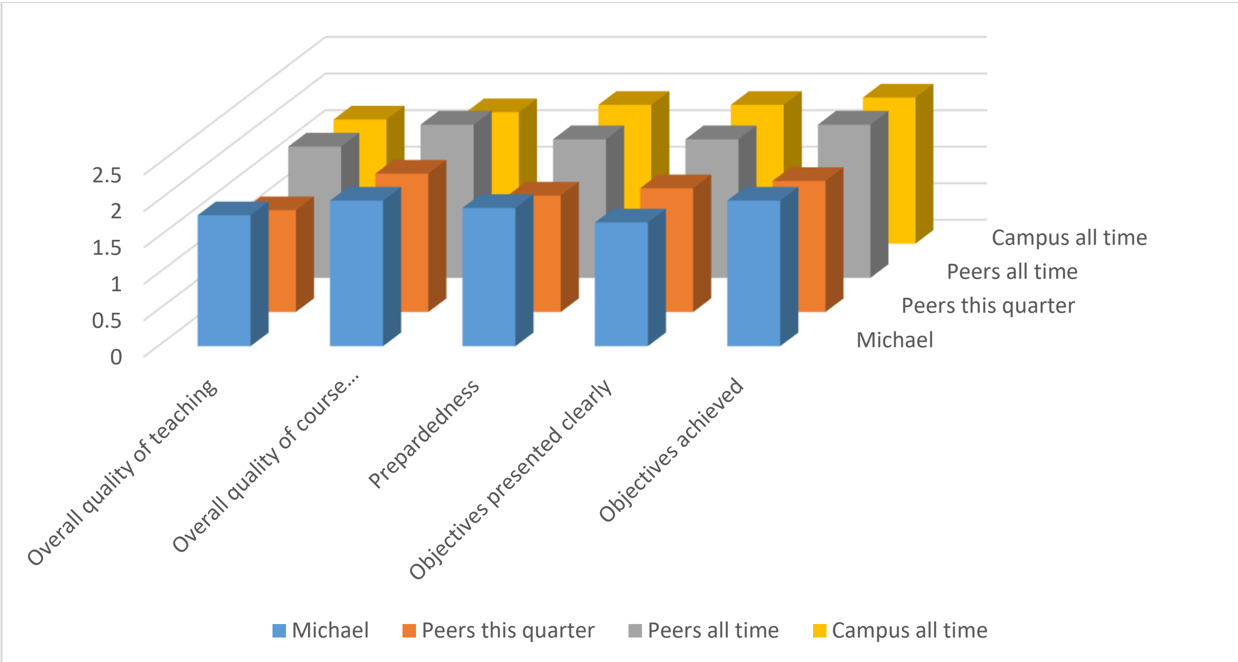


Figure 1. 3-D bar graph of ESCI ratings evaluated. Note that in this case 1 is the most favorable score whereas 5 is the least favorable score.