

Enhancing the Freshman Experience with Upperclassmen Lab Managers: a Win-Win situation

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Freshmen enrolled in Biomedical Engineering at Johns Hopkins University start their academic career with “Modeling and Design”, a two-credit course developed to immerse our freshmen into realistic challenges on day one. Rather than introduce our students to biomedical engineering through lectures, freshmen learn by working in teams of five on modeling and design projects during their first semester. The freshmen projects are open ended, providing students with the opportunity to brainstorm many possible solutions, design their own experimental protocols, perform those experiments in lab, and present the results collectively as a team. These projects incorporate written reports, oral presentations, and class demonstrations. Naturally, some freshmen feel overwhelmed by this approach and the range of potential solutions to each problem. In order to address this situation, we have engaged upperclassmen lab managers to provide technical assistance and support to our freshmen since we first developed this course over fifteen years ago. Each lab manager is completely responsible for a team of five freshmen, including a review of the team’s protocols in lab and assistance during the lab as needed. Lab managers are instructed to guide their students to a solution through questions, rather than directly telling them the best method. More importantly, the lab managers serve as mentors to the freshmen and provide advice outside of the lab on course selection and extracurricular activities. This has been shown to benefit both the upperclassmen and the freshmen¹.

Our BME upperclassmen lab managers prepare for this role by taking a two-credit course, “Effective Teaching and Management of Engineering Teams”, concurrently with their freshmen teaching assignment. For a typical cohort of 130 freshmen, 25-30 BME upperclassmen lab managers work together with the freshmen throughout the semester. End-of-semester surveys for both the freshmen and the upperclassmen lab managers indicate that this relationship has helped both groups of students. For the lab managers this course provides a leadership development opportunity, a small group teaching experience, the opportunity to re-visit material from a new perspective, and a chance to interact with freshmen, peers and faculty in a relaxed setting.

Introduction

All freshmen college students face a range of decisions, including which academic discipline to pursue, which social group to associate with, and which extracurricular activities to pursue, each of which may have a profound impact on their future. Freshmen BME majors at Johns Hopkins face additional decisions including which laboratory to work in and which focus area within BME to pursue. Each student at Johns Hopkins must choose a focus area by the end of their sophomore year, such as cell and tissue engineering, systems biology, imaging, instrumentation, or computational biology. At Johns Hopkins University, freshmen start their BME experience with a mandatory two-credit course, “Modeling and Design”. The freshmen are grouped into teams of five students, resulting in 25-30 total teams. Each team has the same faculty advisor, graduate student teaching assistant (TA), and upperclassmen lab manager. The team-based

format builds an immediate social network for the freshmen that helps support them throughout their college career, both inside and outside of the classroom.

The primary goal of “Modeling and Design” is to engage our students as active biomedical engineers from their very first day at Johns Hopkins. Emphasis is placed on developing critical thinking, problem solving, interpersonal, and leadership skills that are relevant across a wide range of disciplines. Subject specific knowledge is taught through more advanced courses in the subsequent years of their education. The difficulty in challenge-based teaching is that the freshmen students do not have the common foundation in math, science, and engineering they need before they start their projects, a situation encountered in other freshmen biomedical engineering courses².

Course Organization

During the semester, each freshmen team undertake five laboratory modules, in which they design their own experimental protocols, perform experiments in lab, and write reports collectively as a team. Graduate student TAs oversee five to seven of the freshmen teams and are responsible for all of the grading. Every year 25-30 upperclassmen laboratory managers provide appropriate guidance to students and ensure safety in the laboratory. The lab managers also serve as mentors to the freshmen, giving advice on course selection and extracurricular activities, which has been shown to benefit both the upperclassmen and the freshmen¹. Since each team has its own faculty advisor, 25-30 faculty are also involved with the course, and the same faculty advisors will be with these students all four years. In many ways “Modeling and Design” is the foundation for the freshmen’s success in biomedical engineering. A combination of over sixty faculty members, graduate student teaching assistants, and upperclassmen lab managers work together to ensure our freshmen have the support they need to succeed at JHU throughout their academic career.

To ensure that the upperclassmen lab managers are prepared for their responsibility, they are concurrently enrolled in a two-credit course, “Effective Teaching and Management of Engineering Teams”. The lab managers have their own Blackboard website, which includes a copy of all of the course material available to the freshmen. In addition, lab managers have access to the “Faculty Handbook”, which provides background information on each of the five course projects in detail. Prior to the start of the course, all lab managers must complete online courses through JHU’s “myLearning” in lab safety, HIPAA (Health Insurance Portability and Accountability Act), Basic Human Subjects Research, and FERPA (Family Educational Rights and Privacy Act). The course director meets personally with all of the TAs and upperclassmen laboratory managers prior to each of the five projects. During these meetings, the course director goes through the theory and procedures behind each laboratory exercise. These meetings help ensure students have a relatively uniform learning experience and grading criteria.

Five Freshmen Modules

Each laboratory module has a different theme, with three experiments aimed at modeling a certain aspect of the human body (human efficiency, static and dynamic arm, and cardiovascular system), an engineering design exercise using foam core material, and an independent project of the students' choosing. Each of the four mandatory modules are typically presented to students in an open-ended manner. There are videos with background information and some essential facts and equations posted on Blackboard, however, the goal of the course is not to have students follow a detailed protocol to obtain specific values, but rather to design their own experimental protocol. The TAs and lab managers review and approve the protocol prior to the start of each experiment. The five modules are listed in Table 1 below.

Table 1: Five Freshmen Modules

Module	Goal
Human Efficiency Model	Calculate Human Efficiency by measuring output (exercise) and input (oxygen consumption)
Static & Dynamic Arm Models	Calculate the force generated in an arm muscle while stationary and in motion
Cardiovascular System Models	Model flow through a single tube (derive Poiseuille's Law), as well as a system of tubes in series and parallel. Estimate changes in heart rate due to activation of the baroreceptor reflex.
Foam Core Project	Design two simple machines which transport a ping pong ball across a distance of 3 meters and back
Independent project	Build on previous modeling experience to develop equations to model a physiologic system

The course director meets with the lab managers and TAs prior to the start of each module. During these sessions, both lab managers and TAs work through the mathematical equations of each module and practice obtaining data using the available equipment. Lab managers have access to the lab 24/7 and may practice using the equipment on their own prior to meeting with their groups. The role of the lab manager for each of these modules is to ask the freshmen questions to ensure a uniform learning experience. Specifically, the lab managers ask:

1. What mathematical equation(s) will you use to model your system?
2. What assumptions did you make to develop your model?
3. How will you test your model in lab? What experimental protocols will you use to verify the model?
4. How does the predicted data from your model compare with your experimental data? What explains any mismatch; problems with the model? The experimental data? Both?
5. How should you modify the model/experiment so that the model will better match the experimental results?

The freshmen are required to submit their experimental protocol to their TA and lab manager prior to the lab. On the day of the lab, freshmen, lab managers, and TAs work together for two hours to obtain the necessary data. During the course of the experiment, the freshmen often realize that they have not included a critical component in their model and will need to revise their experiment. The lab manager ensures that the team leaves with solid results, assisting each team with data acquisition and analysis as necessary. Lab managers also provide an initial review of the lab report prior to submission for grading. In the end-of-semester survey for the freshmen, over 93% of the students felt “My lab manager was a great resource and helped us obtain and analyze our data in lab.” Some representative comments from the freshmen about their lab managers are listed in Table 2.

Table 2: Freshmen Comments on Lab Managers

X was an amazing lab manager. He helped us with not only the important parts of the class but with BME questions as a whole.
My lab manager made sure that my group was progressing normally during each project and that we all understood each lab.
the lab manager was very helpful and enjoyable to be around. He was informative when it came to the projects and discussed his previous experience often. He could also make us laugh, which was nice to have around when we were stressed out.
Our lab manager was extremely helpful, and really supported us. He provided enough guidance to help us but not too much so as to prevent us from pursuing our own ideas.
Lab manager was helpful, and always sent us reminders via email to sub lab reports and assignments.
Lab manager was often helpful whenever we asked him questions and needed his help. He gave us guidance about future classes as well as the current assignments.
my Lab Manager was wonderful in guiding us and telling us about his personal experience with the course.
The TA and lab managers were fantastic. They were both always available and always had very very useful advice.
X was a great lab manager who always tried to provide insight and help us based on her experience during the course.
Our lab manager was awesome :) I just feel bad that she had to wake up at 8 am with us.
My TA and lab manager were both extremely helpful and patient.
X was our lab manager and she was great! She was very helpful and kind. Give her an A.
X (lab manager) was very helpful with guidance outside of the lab.
X is a great lab manager, she really cares about our group and offers lots of good suggestions on projects and life advice.
X was a great lab manager! He helped guide us in the direction for all the projects. With the independent project especially, he taught us how to use MATLAB, which was a crucial part to our model. He also was our friend and gave us life advice, academic advice, and showed us a couple of restaurants in the Hopkins area.
Lab Manager: Did way more than was expected. Was not only intelligent enough to provide correct feedback, but the right amount as well. Became a great friend and mentor both in lab and out and was someone we respected. Very enthusiastic and supportive.
Our lab manager was amazing. She has become not only a much needed mentor for our entire team but also a dear friend. Without her guidance, I do not know where we would be.
X was really helpful and served as a mentor for the group not only in this class, but just in our general endeavors
X gave good advice about BME in general and was a calming presence for the entire group.
My lab manager was incredibly helpful, but also realistic which helped us set practical goals.
Lab manager: great mentor, helped us a lot throughout the semester and gave us great advice about BME in general
Lab manager did good job leading us along the correct way, but still letting us do most of the work. He also gave feedback on lab reports before submission which was helpful.

Lab Manager Educational Objectives and Assessment

The “Effective Teaching and Management of Engineering Teams” course is an opportunity for upperclassmen lab managers to

- Gain teaching experience in a small group, low-pressure environment
- Provide leadership and mentoring to the freshmen

- Review the basic physics concepts used in biomedical engineering

Table 3 below summarizes the end-of-semester anonymous lab manager survey data from the last two years (2015, 2016; n=52 lab managers) in response to the question, “Was this course a useful introduction to teaching?”

Table 3: Teaching Experience Results

Very much - I learned a lot about teaching from working with the same small group each week	68.18%
Good - I enjoyed working with my group but didn't feel as though I taught them much	31.82%
Average - I don't feel I learned that much from working with a small group of freshmen	0%
Poor - I did not learn anything about teaching	0%

To ensure that our lab managers are successful with each of these objectives, they are assessed through the following criteria:

1. Attendance at five pre-lab sessions to prepare for the upcoming module
2. Attendance at the two-hour weekly sessions with the freshmen
3. Contribution as a grader for foam core project and the final project
4. Mid-semester and end-of-semester survey results from the freshmen
5. Feedback from the graduate student TAs

There are also opportunities for lab managers to earn “extra credit”. All freshmen need to complete an introductory assignment on Matlab, and some of the lab managers offer tutorials outside of class hours to guide students through the Matlab assignment. The freshmen also have a Thursday noon lecture series which introduces them to a variety of opportunities throughout Johns Hopkins. Lab managers can present their research, study abroad trip, and/or design team projects at one of these lectures. Lab managers prepare slides for a short oral presentation, and talk about the challenges and benefits of their experiences. In fact, the student-run Thursday presentations were rated significantly higher by the freshmen compared to the more formal presentations by the Career Center, BME faculty, or other guests. Over 96% of the freshmen felt the lectures on undergraduate research and design team were very relevant to their BME education, with most freshmen rating these lectures as “essential”. The study abroad lectures were rated important by over 84% of the freshmen, as summarized in Table 4.

Table 4: Importance of Thursday noon lectures

Design team	97%
Undergraduate research	96%
Study abroad	84%

After the presentations, freshmen feel comfortable contacting an upperclassmen lab manager for more information on how to participate in these activities.

Table 5 below summarizes the results of the lab manager end-of-semester survey for the last two year (2015, 2016; n=52) in response to the question: “Did you feel prepared for each of the modules (Human efficiency, foam core, cardiovascular, arm, and independent project)?” Over 94% of the lab managers felt they had a solid understanding of the module and how to use the equipment.

Table 5: Lab Manager Preparation

Yes - I believe I knew enough to guide the students in the right direction	37%
Mostly - I needed to clarify a few points with the TAs during the lab session but I could answer all the questions	58%
Somewhat - I should have spent more time on my own preparing for each module	6%
No - even though I went to the prep sessions and read the material I did not know how to help my students	0%

Upperclassmen that successfully complete the “Effective Teaching and Management of Engineering Teams” course received two credits. Based on end-of-semester surveys for the past two years (2015, 2016; n=52), lab managers spent an average of 3.3 hours per week either working with the freshmen in lab on Thursdays or preparing for the modules. Over the last two years, 98% of the lab managers said they would recommend this course to other BME students (Table 6), with a majority of students stating they would recommend being a lab manager to everyone enrolled in BME.

Table 6: Recommend To Other BME Students

Would you recommend this course to other BME students?	2016	2015
Yes - I would recommend this teaching experience to everyone in BME.	82%	57%
Yes - But I would only recommend this course to certain people	18%	40%
Somewhat - only students interested in teaching would benefit from this course	0%	3%
No - I did not think this course was useful for me personally	0%	0%

Based on this data and feedback from the upperclassmen, we believe that our lab managers felt this was a worthwhile learning experience. According to the results of the Johns Hopkins end-of-semester surveys, which are available to all students, lab managers rated the overall quality of the course as 4.6/5.0, where 5=excellent, 4=good, and 3= satisfactory. This is well above the

school level of overall quality of 4.1. In this same survey, when asked about the intellectual challenge of the course, the average response was 4.14, which is essentially the same as the school level. Even though the lab managers had been exposed to all of the material as freshmen, they still believe this was an intellectually challenging course.

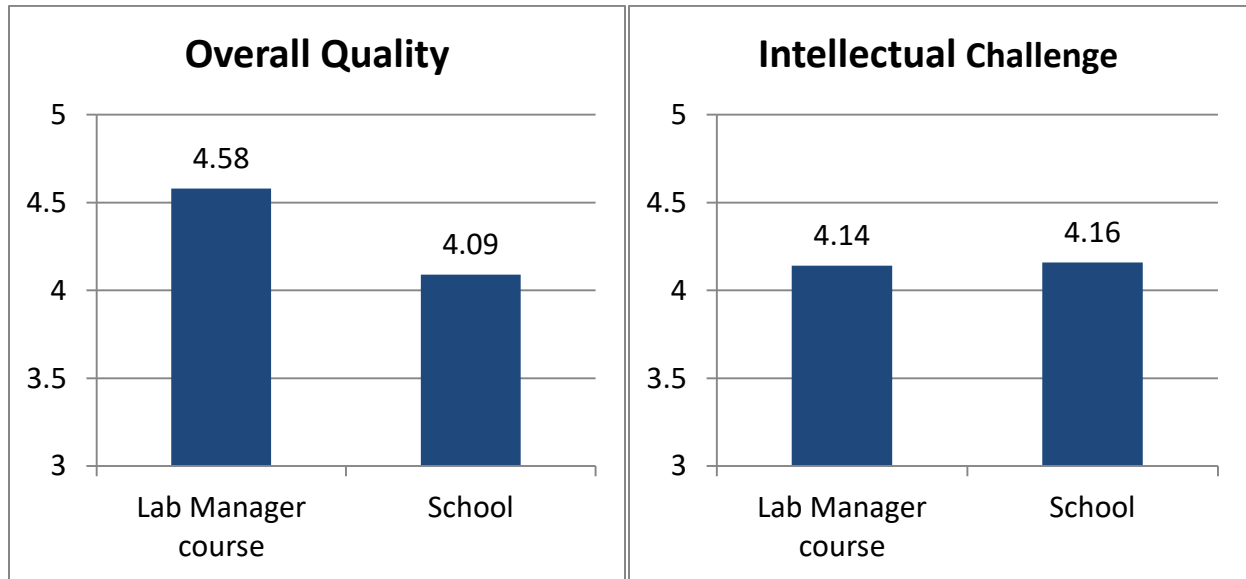


Figure 1: Results of end-of-semester surveys administered by Johns Hopkins University. Overall Quality of the “Effective Teaching and Management of Engineering Teams” course was 4.58/5.0, as compared to school level of 4.09/5.0. The Intellectual Challenge was essentially the same as the school level 4.14/5.0 as compared to 4.16/5.0.

Some of the lab manager comments are listed in Table 7. A common theme was a realization of the depth of their BME education at JHU. The lab managers also had a better appreciation for the role of Freshmen Modeling and Design in preparing them for their future courses and many lab managers mentioned the value of the leadership and mentoring opportunities provided by the course.

The quote below from one of the lab managers really summarizes many of the comments in Table 7. Lab managers enjoy “giving back” to the freshmen and their participation in “Effective Teaching and Management of Engineering Teams” brings them full circle and provides closure to their BME experience. Lab managers have a chance to re-visit the freshman class from an older and wiser perspective.

“Working with the freshmen was the most important aspect of the course to me. Getting to meet with them face-to-face and explain to them some of the lessons I’ve taken away about modeling, and what makes BME both fascinating and important, was a really great opportunity. I remembered that my TA for my modeling and design class, Colin, really helped myself and my fellow freshmen learn about BME both from an academic perspective and also about some of the tips and tools that we all need to learn in order to make it through such a rigorous program. I

was hoping to bring that attitude to the course and help the freshmen assigned to me in those two ways: first, to learn to think through the lens of constructing and analyzing models of biological systems, and secondly to be oriented to the approach and attitude that you need to be able to make it through BME. Being able to transfer that on to my kids was really cool, and it was an awesome experience to be able to watch them work through these problems and improve throughout the course of the semester.”

Conclusion

Lab managers have been an integral part of the freshmen “Modeling and Design” course since its inception. Based on our success with lab managers in “Effective Teaching and Management of Engineering Teams”, the BME department at Johns Hopkins recently started to employ our own undergraduates as paid teaching assistants. We have incorporated many of the training and assessment methods used for our lab managers with our teaching assistants, including a mid-semester survey and the online FERPA course requirement. The undergraduate teaching assistants, many of whom started as lab managers, have enthusiastically reinforced the value of teaching as a learning experience in their surveys. Based on our experience, we believe utilizing upperclassmen as lab managers for a freshmen course is truly a “win-win” situation for all of the students.

Table 7: Lab Manager Comments

I enjoyed re-learning the modules, especially since it has been 3 years since I took the course for the first time. It was interesting to see how the modules in this class were applied to concepts in courses later in the BME curriculum, like SBE.
As a senior looking back on this class, I realized how much it actually sets the stage for some upper level classes, which was really interesting. I was able to appreciate each module and understand its significance to biomedical engineering way more this second time around. It was also a blast working with my team.
The modules are as interesting as they were when I took the course as a freshman, but helping the new undergrads adjust to the rigors of the BME program while ensuring that they have fun makes this class incredibly enjoyable for me.
The modules made a lot more sense looking back // I better understand why we did them now, so I like seeing how this course "primed" me for BME
I really liked re-learning the modules and seeing how everything I've learned so far in BME has built off the labs in modeling and design.
It was interesting seeing how my courses in my later years built on the foundations of courses such as freshmen modeling & design. A good example of this is SBE 1 with the cardiovascular system.
The best part for me was helping teach a course that I had already taken before. It was a very interesting experience to be on the teaching/grading side of all the modules.
It has been great being around freshmen who are excited about their college career and also realizing how much we've learned throughout BME that enabled us to approach the problems more systematically than when we first came into the program.
It's always very fun to work with the incoming freshman, and the course is great practice for learning how to teach/lead a group of people on projects.
It's great getting a retrospect in drawing the connections from our original freshman year classes to upper level classes we take as seniors. I saw that I understood the concepts enough to explain to the freshman what information that should need to know. It was also a great experience in managing the groups expectations and guidance for their work and helping give them focus in sometime ambiguous assignments.
The best part was the opportunity to directly teach the students. I greatly enjoyed instructing the students and learning how to communicate effectively.
The best parts were the opportunity to work with the freshman and the teaching experience. I had never been in a position of authority over other students during my undergrad and I now understand some of the difficulties of teaching.
I really enjoyed working with the freshman and helping to mentor them while introducing them to the major in a low stress environment. I really enjoyed the leadership experience and valued teaching them as well.
I really enjoyed "re-living" my freshman experience. As a tutor, I always enjoy teaching and hearing the students insightful and ever creative ideas.
Having a small group of freshman to help and mentor was the best part. I really connected with my group ,and I feel I helped them with not only with the course work but in choosing classes and other BME/pre-med related topics.
As a lab manager, it was interesting to re-learn the concepts from freshman year, and reinforced them in my mind. However, the best part was probably being able to meet members of the freshman class and learn about them. I feel more connected to their class than the sophomores above them due to lab managing. Additionally as a design team member, I was able to get a preview of the freshmen personalities and capabilities, and get an early idea of who might fit on my design team.
It's really working with the freshmen, and it's also fun seeing how the material all the way back from freshmen year ties together with all the later material.
The best part of being a lab manager is the opportunity to work with the freshman and guide them through their first semester here. I really enjoy mentoring, and being able to answer all of their questions reminds me of how far I have come these few years.

References

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