2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
ASEE
Paper ID #39700

Implementation of Undergraduate Coaches as a Student Resource in a Laboratory Course

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Abstract

Recent years have shown increased success in the use of undergraduate students as teaching assistants or supplemental instructors in core chemical engineering courses. While typically utilized in traditional lecture-based courses, there is significant promise in utilizing undergraduate students as a peer resource in a lab-based course. This paper summarizes how undergraduate teaching assistants, referred to at Louisiana State University as coaches, were integrated into a junior level lecture/laboratory course. The course is designed to teach experimental statistics in the lecture component (two days a week) with the students performing experiments on three different unit operations (one day a week) for 3 four-week experimental cycles. The main responsibilities of the coaches were focused on the laboratory component and include student oversight in the lab, help with debugging lab equipment issues, assistance on data analysis and experimental design, and insight on lab instructor expectations. Undergraduate coaches were recruited during the semester the took the class and served either one or two semesters prior to graduation. The coaches utilized their experience from the class to help the students and are provided additional training on the unit operations used that semester. Preliminary assessment indicated that the undergraduate coaches were an invaluable student resource providing quick answers to questions and encouragement on difficult assignments.

Introduction

Undergraduate teaching assistants (UTAs) have been demonstrated to be a valuable instructional and supportive resource for students and instructors both inside and outside of the classroom [1]. They have been shown to be incredibly helpful in primarily undergraduate universities for decades providing support in both traditional lecture-based classes and lab-based classes [2]. Luckie et al recently summarized the various ways in which UTAs provide support and raise student learning in several ways spanning traditional uses like grading and holding office hours to assisting in the laboratory in both experimental preparation and assistance in experimental design [1]. In a survey of the literature, Luckie and colleagues found that using UTAs in peer-led team learning (PLTL) resulted in higher student motivation, replicated the social nature of performing research, and resulted in students outperforming peers who were not using the PLTL model [1]. These results are supported by several other studies which have shown that UTAs provide benefits to both the students they are instructing as well as themselves [3-5]. While the UTA model has been demonstrated to be effective, one important fact to consider when implementing this model is the requirement for adequate training of the UTAs [6]. Just as with university faculty, UTAs require training in various aspects of pedagogy to ensure their effectiveness as instructors and mentors to the students. Several studies have been published highlighting the need to train UTAs to facilitate active learning and assessment in large enrollment classes [7-8]. Recent studies have also highlighted the need to provide diversity and equity training for engineering UTAs [9]. Kim and Lynch demonstrated how training UTAs and graduate teaching assistants in lab report writing and assessment through a series of workshops helped to increase their effectiveness as instructors [10]. Based on these prior studies, the author decided to implement an UTA model in a junior-level unit operations laboratory course. The

author was able to leverage prior studies to assist in the training and preparation of the UTAs to increase their overall effectiveness in the class. This paper highlights (1) how the UTA model was adopted at Louisiana State University, (2) the responsibilities of the UTAs, (3) how the UTAs were recruited and trained, and (4) preliminary assessment on their effectiveness.

Course design

The three-credit hour course consists of two days of traditional lecture (50 minutes) and one day in the lab (3 hours) and is typically taken during the spring semester of the junior year. The lecture component of the course is dedicated to instruction on statistics, probabilities, and statistical tools. The lab component of the class consists of a two-week experimental workshop (one day per week) during the first two weeks of classes and then three separate, four-week cycles for the remainder of the semester. The experimental workshop provides students with training on all aspects of lab work including experimental design, data analysis, and oral and written presentation skills. The workshop content was developed based on student feedback and observations by the author on what skills the students were missing at the start of the class. Each cycle consists of three experimental days (one day per week) and one presentation day. During each cycle students are split into teams of three (with the occasional two-person team when enrollment numbers are varied) and assigned to a specific piece of laboratory equipment including a heat exchanger network, a viscometer, an Othmer still, a tray dryer, a chiller, or a pump network. For each cycle student teams are given an experimental objective that they must investigate using one piece of equipment. Instruction for the class consists of the primary course instructor (the author) who oversees the entire course and gives the traditional lecture content and lab instructors who each oversee a piece of equipment and are responsible for giving the experimental objectives. The primary instructor also functions as a lab instructor. The lab instructors are a mix of tenure/tenure-track faculty members as well as part time instructors. The time commitment for the lab instructors was to be present for most of lab on day 1, ~30 minutes of instruction on day 2, and then be available to answer questions on day 3. This limited interaction time between instructors and students was a main motivating factor for the implementation of the undergraduate coaches' model (see below for more details on their responsibilities).

Students in the class are graded through a series of deliverables in both the lecture and lab components of the class. Assessment in the lecture component consists of attendance/participation, homework assignments, and two exams (midterm and final). Assessment in the lab component of the class consists of four key deliverables for each cycle including a Day 1 Assessment, Day 2 Update, oral presentation, and written report. These deliverables are submitted either individually (Day 2 Update and oral presentation) or as a team (Day 1 Assessment and written report). The individual deliverables are submitted once per semester (e.g., Student A gives the Day 2 Update in cycle 1, the oral presentation in cycle 2, and nothing in cycle 3) where the team deliverables are submitted by the team in all three cycles. The mid-cycle deliverables are designed to provide the students with feedback to help them during experimentation and as they work towards presenting their findings from each cycle. The Day 1 Assessment takes place on the first day of lab during the first ~30 minutes of class. It is given verbally by the lab instructor and covers all aspects of the experiment including theory, experimental protocols, safety guidelines, the type of data that will be collected, and proposed

statistical analysis (to connect with the lecture component of the course). This deliverable is intended to encourage the students to arrive at the lab prepared and ready to begin experimentation. The Day 2 Update is submitted as an ~6-8-minute video PowerPoint presentation two days after the second lab day. The goal of this deliverable is for the student to provide an oral preliminary report where the lab instructor can provide feedback on experimental plans and preliminary results as well as insight on how to plan for the third and final lab day. The use of the video was to give students additional opportunities to improve their oral presentation skills while preventing any loss of lab time. The ~10-12 min oral presentation is given during the scheduled lab period and is graded by both the primary instructor and lab instructor. The written report is due 24 hours after the oral presentation so that students can use the questions and feedback given by the instructors during the Q&A session of the oral presentation to enhance / improve the written report. The development of these deliverables was based on the feedback from current and former students from Louisiana State University currently working in industry to provide essential training in how engineers communicate findings. Each deliverable also had a detailed grading rubric to help achieve uniform grading across the different lab instructors.

Responsibilities of undergraduate coaches

Given the complex nature of the course, the abundance of instruction required of the students, and the numerous graded deliverables described above, the author decided to implement the undergraduate coaches model as both a resource for the students and the instructors. The primary responsibility of the coaches was to function as a resource in the lab and, as such, they were present for the entire lab period. A typical lab day (e.g., Monday – Thursday) consisted of 3-5 student teams which were overseen by two coaches per day. This required a total of four coaches per semester with two coaches in lab on Mondays and Wednesday and the other two in lab on Tuesdays and Thursdays. The coaches were responsible for (i) maintaining and (oftentimes) debugging equipment, (ii) helping with reagent preparation, (iii) locating reagents/supplies, and (iv) showing students how to use the equipment to collect data. To make sure that the teams were always on track, the coaches would check on each team every ~15-20 minutes. This policy was put in place because we observed that many times the students did not know what they did not know and were hesitant to come and ask for help (although we found this phenomenon to decrease in the later cycles). The coaches were also responsible for signing off on the shutdown checklist for each piece of equipment as a layer of redundancy to make sure each unit was turned off correctly.

In addition to overseeing the lab work, the coaches also served as a level of support with respect to the lab deliverables. As all the coaches had previously taken the course (see below for details on recruitment and training), they were well versed on the various experiments and the types of objectives that were associated with them. As such, the coaches could provide insight on how to analyze the data in addition to the underlying theory accompanying each experiment. Another valuable aspect of the coaches is that they were familiar with the various expectations of the different lab instructors. During the multiple semesters the author taught the course they observed that some of the lab instructors emphasized different aspects of the experiments (e.g., a greater emphasis on theory versus results), had different expectations for the types of statistical tools used to analyze the data, provided varying degrees of support (e.g., go look it up on your own versus personal instruction), or had varying degrees on what course content the students had

mastered (e.g., they had not yet gotten to mass transfer in the transport class they were taking co-currently). Based on their experience in the course, the coaches were able to instruct the students on these different expectations, oftentimes prior to day 1, to help them better prepare for lab and better prepare their deliverables. We found this to be particularly helpful in preparing the students for the Day 1 Assessment with the student teams meeting with the coaches prior to the start of lab.

The responsibilities of the coaches were dramatically impacted by the COVID-19 pandemic. The semester the coaches model was adopted in the class was the spring 2020 where Louisiana University shut down in-person classes in the middle of the semester. The coaches were invaluable assets for the primary and lab instructors as we all transitioned a lab course from traditional in-person instruction to a virtual experience. The coaches helped to generate mock data, to replace the in-person data the students would normally get, and uploaded the data to a cloud storage device. This was put in place so it was like the students had generated the data themselves and could proceed with analysis and interpretation. The coaches also served as support staff during the virtual oral presentations on Zoom in case issues arose with the primary and secondary instructors. The 2021-2022 academic year found Louisiana State University switching to a hybrid format with limited staffing. This meant that two out of three lab members were allowed to be in the lab working on the equipment while the third lab member had to join via Zoom. Since each team was down a member, the coaches helped to backfill some of the in-person activities as some experiments require three people working on various aspects of the unit. Without the coaches, the students would not have been able to collect sufficient data. Additionally, some of the lab instructors were not able to come to campus due to COVID-19 guidelines which meant that the coaches were the only in-person instructors that the students interacted with while the lab instructors communicated with the students using Zoom. Having the coaches present helped to overcome many technical and technological challenges with both the lab equipment and Zoom.

Recruiting and training of undergraduate coaches

All the undergraduate coaches served in the position for 1-2 semesters. This is because the course is offered during the third to last semester of the students' degree progression and the coaches are always recruited from students who have already taken the course. For the first two semesters (spring 2020 and fall 2020) the author had to directly contact senior undergraduate students and ask them if they were interested in serving in the position. This is because the concept of the UTA/coach in the lab course was new, and many students did not know what the responsibilities included. The author was able to identify four senior students for the spring 2020 offering (two who were graduating in spring 2020 and two who were graduating in fall 2020). The two students with the later graduation date agreed to stay on for the fall 2020 semester only requiring the author to reach out to new students again prior to the start of the fall 2020 semester to maintain the desired number of four coaches. After the fall 2020 semester the position had garnered enough popularity among the undergraduates that the author had students reaching to them to ask to serve as a coach. As such, recruitment for the coaches positions became easy starting with the spring 2021 semester until the spring 2022 semester with nearly twice as many students asking to serve in the role. With respect to the attributes the author looked for in the coach, there were four key features: (1) the prospective coaches had to have performed well in

the course (minimum grade of B), (2) they had to have shown mastery of the equipment they worked on while in the course, (3) they had to be outgoing and willing to engage with the students in the class, and (4) they had to exhibit a willingness to teach the students in the course without just giving them the answer. The author used a combination of observing the students when they took the course and an informal interview with the perspective coaches to address these four criteria in terms of selection of the coaches. After the coaches were recruited, they were then added to the payroll of the Department of Chemical Engineering which provided financial support for the students in the form of an hourly wage with a weekly workload of ~8-10 hours including working with the students inside and outside of the lab.

After the coaches had been recruited, they were then trained in all their responsibilities described in the previous section. Prior to the start of every semester, every new coach was given specific training on the operation of each of the experimental apparatuses. This training was given by a staff member from the Department of Chemical Engineering whose responsibility was to oversee the unit operations lab and the equipment it housed. Coincidently this staff member also served as a resource when equipment broke or malfunctioned beyond a simple fix that could be performed by the coaches. During this training the coaches were instructed on common issues that could arise with the equipment in addition to general tips on how to troubleshoot the equipment. Each piece of equipment already had an existing operating manual generated by the staff member which served as a resource for both the coaches and the students. Since the coaches had already taken the course, they had previously been trained on the lab safety requirements and expectations of the unit operations lab. Similarly, the coaches had been trained in effective oral and written communication through a series of workshops given when they took the class during the previous semester. As such, they had both the resources and training to help answer questions related to how to best prepare for and deliver all the lab deliverables.

Finally, the coaches were given specific training by the author (and primary instructor) on the differences between appropriate and inappropriate assistance. The author had the students view a series of educational videos they generated and read a paper on their overall effectiveness written by the author to see the impact of appropriate versus inappropriate aid [11]. Next, the author met with each coach and gave them instruction on how to answer questions related to experimental design, data analysis, and written and oral communication to outline course expectations. The coaches also sat in on the experimental workshop during the first two weeks of class to observe how the author instructed students on these items to further reinforce course expectations. Finally, the author would regularly go to the lab during each experimental cycle to observe how the coaches interacted with the students to ensure that inappropriate assistance was not given. The author also asked students about resources (and resource sharing) available to students to learn more about what was out there. Interestingly, the author found that most students did not share lab reports between years (which was honestly quite shocking).

Preliminary assessment

It is important to note that the assessment provided in this paper is preliminary due to a limited amount of data collected at this point. This is because formal assessment of the undergraduate coaches model at Louisiana State University just started during the spring 2023 semester when the author elected to present on the undergraduate coaches model at the ASEE conference. As

such no formal assessment data was collected during or after the semester where the author implemented the model from the spring 2020 to spring 2022 semester. One challenge the author has run into in terms of collecting this assessment data is that many of the students from the classes (and the coaches themselves) have already graduated which has made data collection difficult. As such, assessment on the undergraduate coaches model is currently ongoing with the author planning to have a complete data set to present at the annual meeting. The undergraduate coaches model was started by the author in the spring of 2020 (72 students) and then used in the fall 2020 (42 students), spring 2021 (57 students), fall 2021 (21 students), and spring 2022 (41 students) semesters after which the author was taken off of teaching the course. The author created two online Qualtrics surveys that were recently released to current and former students who took the course and worked with the undergraduate coaches. The first survey was designed to assess the effectiveness of the coaches (***Appendix A***). It included a series of questions using a five-point Likert scale (strongly agree to strongly disagree) related to how the coaches helped the students in the lab, when completing the lab deliverables, when working with the lab instructors, with course content, and overall successful performance in the course. A second survey was designed to assess the impact of the coaches model on the undergraduate coaches themselves (***Appendix B***). This survey included a series of questions, also used a five-point Likert scale, that asked how being a coach helped the student to prepare for their future career and to develop technical and soft skills. Both surveys are still collecting data that will be presented during the presentation at the annual meeting.

Prior to implementing the formal assessment instrument in the spring 2023 semester, the effectiveness of the coaches was assessed informally during mid-semester evaluations and final course evaluations. The questions related to the coaches were more qualitative, asking for general feedback. The most common responses from the students were (i) they were able to answer questions, (ii) easy to talk to, (iii) always checking in on the teams to provide help, (iv) willing to help, (v) able to provide insight on the course, and (vi) very encouraging.

Conclusions

The paper outlines the design and implementation of an UTA model in a junior level lab course. The undergraduate coaches model was found to be highly successful based on informal student feedback with most students in the class supporting the peer resource as an invaluable tool to help them navigate a complex and challenging course. The coaches model was also found to be very helpful to maintain continuous student instruction while minimizing some of the teaching commitments of the lab instructors assigned to the course. The author hopes that the message from the paper serves as a potential tool for other lab instructors who may choose to implement a similar model in their course.

References

[1] Luckie DB et al. Undergraduate teaching assistants can provide support for reformed practices to raise student learning. *Adv Physiol Educ* 44:32-38 (2020).
[2] Fingerson L, Culley, AB. Collaborators in teaching and learning: undergraduate teaching assistants in the classroom. *Teach Sociol* 29:299-315 (2001)

[3] Close EW et al. Becoming physics people: Development of integrated physics identity through the Learning Assistant experience. *Phys Rev Phys Educ Res* 12: 010109 (2016)
[4] Gafney L, Varma-Nelson P. Evaluating peer-led team learning: a study of long-term effects on former workshop peer leaders. *J. Chem Educ* 84:535-540 (2007).
[5] Magolda MB, Rogers JL. Peer tutoring: collaborating to enhance intellectual development. *Col Stud J* 21:288-296 (1987).
[6] Guadagni G et al. The benefit of training undergraduate teaching assistants. *ASEE Annu. Conf. Expo. Conf. Proc.,* vol. 2018-June 2018. Paper ID 23848
[7] Ruder SM, Stanford C. Strategies for training undergraduate teaching assistants to facilitate large active-learning classrooms. *J. Chem. Educ* 95:2126-213 (2018)
[8] Ruder SM, Stanford C. Training undergraduate teaching assistants to facilitate and assess process skills in large enrollment classes. *J. Chem. Educ* 97:3521-3529 (2020)
[9] Paredes I et al. Work in progress: Diversity & equity training for undergraduate engineering teaching assistants. *ASEE Annu. Conf. Expo. Conf. Proc.,* vol. 2022-June 2022. Paper ID 37791
[10] Kim D, Lynch JD. Perspectives and practices of undergraduate/graduate teaching assistants on writing pedagogical knowledge and lab report evaluation in engineering laboratory courses. *ASEE Annu. Conf. Expo. Conf. Proc.,* vol. 2020-June 2020. Paper ID 29040
[11] Melvin AM, Bullard LG. Fifteen years in the trenches: An updated suite of scenario-based academic integrity videos. *Chem. Eng. Edu*. 55:137-145 (2021).

Appendix A – Coaches Evaluation Survey

Q4

Experiments you worked on

- [ ] Heat Exchanger
- [ ] VLE
- [ ] Viscosity
- [ ] Chiller
- [ ] Tray Dryer
- [ ] Extruder
- [ ] Mass Transfer
- [ ] Microfluidics
- [ ] Pump Network

Q5

In working in the lab, the involvement of the undergraduate coaches helped me and/or my team

	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
With experimental preparation	○	○	○	○	○
With experimental design	○	○	○	○	○
With data collection	○	○	○	○	○
With data analysis	○	○	○	○	○
To debug issues with experimental equipment	○	○	○	○	○

Q6

When working on the lab deliverables, the involvement of the undergraduate coaches helped me and/or my team

	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
Prepare for the Day 1 Assessment	○	○	○	○	○
Preparing the Day 2 update	○	○	○	○	○
Preparing the Oral Presentation	○	○	○	○	○
Preparing the Written Report	○	○	○	○	○
Resolve any conflicts or communication issues between teammates	○	○	○	○	○

Q7

When working with the lab and course instructors, the involvement of the undergraduate coaches helped me and/or my team

	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
Interpret the lab instructor's objectives / assignment	○	○	○	○	○
Interpret the lab instructor's expectations for the type of data and its analysis	○	○	○	○	○
Interpret the lab instructor's expectations for the lab deliverables	○	○	○	○	○
Interpret the course instructor's expectations	○	○	○	○	○

Q8

The undergraduate coaches helped me master course content (e.g., statistical tools and concepts)

- ○ Strongly Agree
- ○ Agree
- ○ Neither agree nor disagree
- ○ Disagree
- ○ Strongly Disagree

Q9

The undergraduate coaches helped me to succeed in the course

- ○ Strongly Agree
- ○ Agree
- ○ Neither agree nor disagree
- ○ Disagree
- ○ Strongly Disagree

Q10

Please list three adjectives you would associate with the undergraduate coaches

Appendix B – Former Coaches Survey

Q2

Being an undergraduate coached helped me

	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
To prepare for future courses	○	○	○	○	○
To prepare for my future career	○	○	○	○	○
To develop my written communication skills	○	○	○	○	○
To develop my oral communication skills	○	○	○	○	○
To develop my ability to design an experiment	○	○	○	○	○
To develop my ability to analyze / process data	○	○	○	○	○
With my ability to deal with conflict	○	○	○	○	○
With my ability to deal with different types of supervisors	○	○	○	○	○

Q3

I enjoyed serving as an undergraduate coach

- ○ Strongly Agree
- ○ Agree
- ○ Neither agree nor disagree
- ○ Disagree
- ○ Strongly Disagree

Q4

What did you enjoy most about being an undergraduate coach

Q5

What was your biggest challenge in being an undergraduate coach