ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Paper ID #35666

Peer teaching research group model for upper level environmental engineering class with student-led lectures and journal article discussions

Dr. Thomas S. Soerens, Messiah University

Thomas Soerens is Professor of Engineering at Messiah University. He teaches in Civil and Environmental engineering with specialization in storm water, ground water, and water treatment. He performs design and applied research in water systems in rural developing communities. He is a Professional Engineer and a Certified Ecological Designer.

Peer teaching research group model for upper level environmental engineering class with student-led lectures and journal article discussions

Abstract

An upper level environmental engineering class focusing on hazardous waste and air pollution was organized to mimic a graduate school research group. It is an upper-level required class for environmental engineering majors. In most weeks of the MWF class, a different student each week prepared a lecture and taught that week's material on Monday. On Wednesday the faculty member followed this up with more explanation and clarification. Friday was a class discussion of a journal article related to the topic. The student would prepare the lecture a week or so in advance and faculty member and student would meet the previous week to go through what they had prepared. The student was directed to work at least one example problem from the text and to assign at least three text problems. The faculty member chose the journal article for each Friday and the students were responsible for reading it before class. The class format was well received and all students rose to the challenge and presented good lectures. A year later elements of this model were used in a water and wastewater class that had three students from the previous year's hazardous waste class. Although there are not enough data to make strong conclusions based on these initial offerings, the next offering of the course will include feedback from students during and after the course so the faculty can monitor impact of the graduate research model in undergraduate courses.

Introduction

Graduate school is an intense but exciting time of learning, exploring, delving deeply into a subject that you feel you hardly understand at first and coming out of it with deep specific knowledge. You learn from your mentors, fellow students, and other investigators in your research group. You learn how to give and receive feedback and criticism. You learn how to critically evaluate others' research in your group and in the literature. And you learn how to incorporate feedback into your own research. You will gain knowledge in a specific sub-area in your field more deeply than even the others in your research group. Hopefully you eventually make a new contribution in your field.

The University does not have a graduate program in engineering. The motivation for moving to a graduate research group model for the class was to give the students a microcosm of graduate research group experience.

The goals of implementing this model were to increase capabilities, skills, and learning needed to

1. Digest and disseminate new information in a clear and organized manner
2. Select appropriate illustrations and exercises to teach the topic to others
3. Critically evaluate a research journal article from the literature
4. Delve deeply into a topic of interest

The model was implemented in an upper level environmental engineering class of eight students.

Course Description

The course is a three credit upper-level environmental engineering class on hazardous waste management and air pollution. The course focused on the fundamentals of transport and fate processes in air, soil, and water as well as on treatment strategies and technologies. The class was offered for the first time in spring of 2020, meeting three times per week (MWF) for the twelve-week session. It is one of two classes exclusive to the environmental engineering concentration. The course objectives are to:

- Classify hazardous wastes based on makeup, toxicity, and regulation status.
- Assess sites containing hazardous waste following federal and state guidelines.
- Identify transport and fate processes affecting contaminant presence and movement in soil, air, and water.
- Quantify concentrations and masses of contaminants in different media (soil, air, water) based on chemical and media properties.
- Evaluate a hazardous waste site and design processes to undergo mitigation.
- Identify types and examples of air pollutants and identify their hazards and the appropriate treatment processes.
- Design an air pollution control process for a specific scenario.

The course used a textbook, Watts, R.J. *Hazardous Wastes: Sources, Pathways, Receptors*, that closely fit the course design. Each of the eight students selected from among a list of topics relating to the course objectives. Seven of those topics were specific chapters in the text; one was based on a case study from public record. The student lectures were given on Mondays. The students met once with the professor on the preceding Friday to go over the material. Students were asked to work at least one example from the text in their lecture and to assign at least three homework problems from the text. The professor then added problems to fill out the homework assignments. On Wednesday, the professor lectured and provided in class exercises on the same topic as the Monday lecture, clarifying and filling in the topic material.

The students were not graded on the lectures. The hope was that, like in a graduate student research group, their peer group would inspire them to do it well.

Each Monday a paper from the literature was given to the students to read and review for discussion during Friday's class. This mimics an assigned paper review meeting that the course professor had with their research group in graduate school. There was no submission for the paper reviews and they were not graded but only used for classroom discussion.

Similar Models

Kendall and Williams [1] describe Peer Designed Instruction (PDI), which deviates from other collaborative learning approaches in that "the authority in the classroom shifts from the faculty member(s) to Student Instructors". The student instructors are students who previously completed the course, not students in the course at the time. The student instructors are responsible for the educational material, design, and content delivery of the classroom learning experiences. Students liked much about the approach, finding the student instructors "personable", "friendly", and "approachable", but students also found the student instructors amateurish and inexperienced, making comments related to unpreparedness, disorganization, and unclear expectations. Suggestions included having the professor lead the course and having the student instructors as secondary instructors. The model in this paper differs from the Kendall and Williams model in that the professor remains the main instructor and only about one-fourth of the lectures are delegated to students with the professor providing oversight and collaboration.

Bailey [2] used a peer-teaching pedagogy in a laboratory course. Different student groups performed different labs, practicing and troubleshooting to become the experts for a specific lab. So each team was the expert for a given lab. Then they served as expert teaching assistants as other lab groups performed that lab in later weeks. The students reported that they learned a lot about their labs and also developed skills in troubleshooting and in teaching others. One interesting response was "While I did like the expert lab experience, I feel like I learned more about the one that I was an expert in rather than all the other ones". As students performed the labs under other students' guidance, they, like in the Kendall and Williams [1] study, made comments related to the amateur status of the student instructors. Bailey [2] made iterative changes to the model over the next couple years. Interestingly, the author reports "Meaningful learning occurred while perceived learning declined compared to Year 1". The likely factors may not be related to the peer-teaching model but to other changes. The author recommends that "This technique of inquiry-based learning followed by peer-teaching is highly recommended but with very close monitoring by the instructor. The students in this program almost always have an instructor present in the classroom or lab."

Results and Observations – student lectures

In this study, the students did a good job overall in digesting and then teaching the topics. One student, whose performance and interest in other classes had been marginal, took a keen interest in his topic and prepared and delivered an excellent, thoroughly document, well organized and engagingly presented lecture. Even though they were not graded, the students, some of whom were excellent students in past classes and some who performed poorly in the past, all took it seriously and did a thorough job on it. The students readily volunteered to take their turn. It did seem that the peer group inspired them to step up when it was their turn. One student commented in later follow-up that the small class size and the fact that they knew each other well made the process better.

When the course was forced to go remote for the second half of the spring 2020 semester, several students expressed concern that the student lecture days would be scrapped and emphasized how much they liked those lectures. The practice was continued with Zoom sessions while remote.

One unexpected positive was that the students often emphasized different aspects of the topics and made insightful observations that were new to the faculty. The negative flip-side of that was that it was more work for the faculty member to convey important points that the student did not cover, especially while having to "catch up" from the period that was "lost" to the student lectures. Those words are in quotes because perhaps there is value in building in some flex time for the "lost" time and perhaps the professor's preconceived beliefs in which parts of the topic are most needed should be stretched. The low enrollment is important not only to facilitate a small group feel, but with more students there would not be enough class periods or class time for each student to have a full slot to teach a topic.

The "lost" time could be reduced by more rigorous screening of the lectures during the meetings the previous Friday and requiring them to be mostly finished in preparation. Often the student had only partially prepared at that point and as long as they were on the general right track, they were given the go ahead to proceed. During the class lectures, the students sometimes got caught up in tedious unit conversions or other tasks that took up class time and were not central to learning. More structure and direction for the lectures would be productive for future offerings; this was reiterated by students in their comments.

The text used tracked closely with course topics and objectives, which facilitated the lectures. These days many instructors eschew required texts, preferring to prepare their own material compiled from different sources and/or written themselves. For the student lectures, it helped to have a text book providing a constrained choice of good material along with consistent terminology and approach. There was no solution manual for the text and this was the first offering of the course. Sometimes the homework problems selected by the students, although they looked appropriate at first screening, turned out to be too complex or were tangential to the desired focus for the topic. Requiring the student to provide a solution to the problem before the lecture would help avoid this issue. A new issue of the text is due soon [4].

Results and Observations – paper reviews

It was challenging to find journal articles that were accessible enough to undergrad non-experts in the field without being lengthy literature reviews. The students did make insightful observations and valid criticisms of the papers. It did seem that the students read the papers. The students were more critical and more confident of their opinions than expected and could back up their criticism with defensible reason.

However, it did not seem that the paper discussions were good use of limited class time, especially not devoting an entire lecture period to the paper. Spending the whole Friday period on a paper was not an efficient way to fulfill the objectives of the course. The Friday paper sessions were discontinued toward the end of the semester, especially since going remote made

conversing more awkward. The informal discussions could be replaced with specific instruction on how to evaluate a paper along with a paper review assignment completed outside of class with a short discussion in class.

Follow-up and Student Feedback

In a water and wastewater class a year later (ongoing as of this writing), student lectures were also used. The students selected from a list of course topics and were instructed to prepare a approximately twenty minute (about half of a class period) lecture. The research paper meetings were not done in the water and wastewater class. Three students in the water and wastewater class were also in the previous hazardous waste class. These students were asked to reflect on the two experiences and were specifically asked if the lectures should be graded and if more guidance should be given. Below are some comments.

- "I will say though that I knew the stuff I taught on much better than the stuff my classmates taught."

- "I think doing it again would be very beneficial for the future class."

- "I think a general structure for the lecture would be very helpful for preparing, but since each chapter is very different a loose structure would be best."

- "I liked it, I think that it helped me engage in the content."

- "I liked how it was done in HazWaste (than in water and wastewater) more since it was more in depth with examples."

- "Overall in a small class I think it works well. Specifically since it was only Environmentals so we knew everyone pretty well."

- "The Haz Waste lectures were more in depth than Water Wastewater."

- "A rubric or even just a list of requirements would probably help with making the lectures more in depth."

- "I definitely believe doing the lecture made me understand the material better so I would suggest doing the student lectures again for Haz Waste and Water Wastewater in the future."

Some common aspects came through in the comments. They would appreciate more direction and accountability in the lectures. They seemed to get more out of the full lecture requirement in the hazardous waste class than in the shortened version in the water and wastewater. The process helped them engage their specific topic in more depth. They all had positive experiences. It was

interesting that a student mentioned that the small size and knowing each other well was a key to their positive experience. As in the hazardous waste class, the students emphasized different topics and had different insights than the instructor had, opening up the instructor's mind to different ways of looking at and of teaching the material.

Future Plans

Based on the experiences and feedback, plans for the next offering of the course include:

- Formalizing the lecture assignment
    - Give a grade for the lecture
    - Provide a rubric and suggested structure for the lecture
    - Require the lecture to be complete by the pre-lecture meeting with the professor and provide more rigorous review and recommendations
    - Require the student to submit solutions to the homework problems selected
    - Incorporate peer review into the lecture assessment

- Converting the weekly class period paper discussion to a few homework assignments
    - Offer instruction on how to evaluate a journal article
    - Require a written review of a journal article
    - Take a short time in class for discussion of the paper

- Include evaluation of the student lecture assignment in the formal assessment
    - Create an assessment in addition to the standard IDEA forms
    - Invite open-ended feedback from students

It is possible that turning the ungraded tasks into graded assignments could lose the research group aspect and feel of the model, but this would tighten up some of the inefficiencies in course delivery by this model. Inspired by the esprit de corps of the spring hazardous waste class, for a fall upper level course with small enrollment of nine, the course project had loosely defined roles in the hope that students would step up and run with the project. As it turned out, a couple students stepped up, but most others used the looseness to avoid doing their share of the project. So it could be that the spring group was the exception or maybe it is the nature of lecturing on a new topic that interested the students. The spring group was a closer-knit cohort, so that may be an important factor. Regardless, normalizing the expectations would help keep all students engaged at an appropriate level.

This one small class was not enough students to do a quantitative assessment of learning. Also, the specific assessment and dissemination to others of this model was an afterthought, so only the normal scheduled assessments were initially done. A follow-up with three students a year later did elucidate and reiterate some of the observations. Future offerings, or use of this model in other courses, will include a more formal assessment.

Summary and Recommendations

The graduate research model appeared have positive impacts on student engagement and learning. It also gave the faculty member a fresh perspective and a push out of the rut of preconceived ideas of what to emphasize. It was a small class of only eight students. A text book that closely fit the course topics helped facilitate the student lectures. It would seem that this model would work best for small classes of upper level students in their specialty area, although this should not constrain the use of this approach in other educational settings. This was the first offering of the course, the model will be modified for future offerings. Aspects of the model may be tried in other upper level specialty classes with small enrollments. It is recommended that the graduate research group model be considered for courses that have the following attributes

- Low enrollment
- Upper level technical specialty
- Good text book or other collection of constrained reference material

Using the research group model for the hazardous waste class was a positive experience for the students and for the instructor and using aspects this approach for a course with these specific attributes may invigorate students and instructors in such courses. Although there are not enough data to make strong conclusions based on these initial offerings, the experience and the feedback from the few students were encouraging. The next offering of the course will include feedback from students during and after the course so the faculty can monitor impact of the graduate research model in undergraduate courses.

References

[1] Kendall, M.R., Williams, M.C., (2017) "Student Motivation in a Peer Designed and Delivered Course", *Proceedings of the 2017 ASEE Annual Conference, Columbus, Ohio, June 25-28, 2017*.

[2] Bailey, J., (2018) "Exploring an Inquiry-based Learning with Peer-teaching Pedagogy in a Physiological Signals Lab Course", *Proceedings of the 2018 ASEE Annual Conference & Exposition, Salt Lake City, Utah, June 24-27, 2018*.

[3] Watts, R.J. (1998) *Hazardous Wastes: Sources, Pathways, Receptors*. John Wiley and Sons.

[4] Watts, R.J. (2020) Personal Communication