



Impact of Mentoring and Coaching on Student Performance in an Operations Research Class

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Operations Research (OR) provides essential set of core skills needed by Industrial Engineers. However, teaching its mathematical and theoretical foundation and concepts creates challenges for both instructor and students. Teachers in a one semester class usually concentrate on providing the procedural understanding of the use of the mathematics and algorithms rather than the concepts and applications due to the time constraints and knowledge level required for complex and intricate modeling issues beyond simple models.

Based on an innovative design^[1] of the course's delivery and instructional methodology, founded on a cognitive learning model, the general concepts of coaching and mentoring to enhance student learning were used. Both concepts have been widely studied and the education community considers them among proven techniques to enhance learning and skill development^[2]. It is not the purpose of this paper to demonstrate whether coaching and mentoring is useful, rather to report the approach undertaken in employing such tools and observations and analysis of a one semester experiment with this approach.

The overall discussion in this paper is divided into five sections. Section 1 contains discussions of the structure and methodology of the unique delivery system of our OR course. Section 2 includes discussion on the characteristics of the student body of the class and history of the student performance in the course. Section 3 comprises the assessment and feedback method for the course and their impact on the dynamic evolution of it. Section 4 provides the details of the mentoring and coaching system we implemented. Finally, section 5 reports the observation and analysis of the experiment and our plans for future experiments with the model.

Section 1: The OR Course Structure

The course is divided into ten topics. These topics are mostly what majority of the textbooks consider as essential elements of OR curriculum for an undergraduate OR class. Each topic is built on knowledge and skill gained in prior topics while building the foundation skill and knowledge set for succeeding topics.

These topics are:

- Finding Feasible Regions
- Extreme Points, LP and Its Standard Form
- Writing LPs from Feasible Regions
- Simplex Method
- Simplex Method - Big M Method
- Simplex Method - Two Phase Method
- Matrix Representation of LP, Its Solution and Tableau Structure
- Revised Simplex Method
- Sensitivity Analysis
- Duality.

Transportation Problem and Transportation Simplex algorithm were also covered as an extra topic.

Each topic is usually covered in one week during two class sessions. Extensive set of solved problems with a rich archive of homework and test problems from previous semesters are also available through the instructor Web site ^[3]. Class sessions are video recorded and made available to the students on a set of department lab computers without editing. Edited versions of the topics selected from better recordings throughout the years are also posted to the instructor YouTube channel ^[4]. Students are required to study the topics prior to attending the class session. They are encouraged to create and participate in study sessions and are rewarded (though intangibly) for active participation in group discussion forums through the class Google group forum.

Upon completion of a topic lecture, the class is placed “On the Clock” giving them one week to accomplish two tasks. The first task is the Practice Presentation. In this stage each student selects a problem of his/her own choice, solves it and then present it to the instructor. This is a one-on-one session with the instructor at which the instructor assesses student’s level of understanding of the concept and his/her demonstrated skill level. Points and hints that can help deepen understanding of the subject in the form of “what-if” questions along with corrections that may be needed are also discussed in this session.

When a student passes this stage, a homework problem is assigned to him/her. This homework problem is designed for each student individually and although it has the same set of instructions

and requirements, yet the problem assigned is different for each student. A student receiving a homework assignment has 24 hours to submit a solution for that homework. Students who pass the homework assignment successfully will take a test problem on that topic. It is important to note that the homework problem is usually a larger problem requiring at least 2-3 hours of work. However, all the tools, solved sample problems, software to check the solution, and more are available to the students.

The topic test is usually one problem to be solved in a 20-30 minute class time and it is given to all students who have passed that topic. Although fast-paced, this method affords students an opportunity to pass a test on a consolidated segmented amount of material in a synchronized timeframe. To pass the course, each student needs to pass at least 7 topics for a grade of “C” with 8 and 9 topics for grades of “B” and “A” respectively.

Additional Bonus Topics have also been offered to enhance students’ chances of passing the course successfully while adding to the knowledge set delivered for the class, thus enriching students’ learning.

Section 2: Demographics and Performance

The school itself is a member of Historically Black Colleges and Universities (HBCU). Although, due to its location and reputation, many high profile students select it for their education, in general, majority of student body require remedial courses in Math and English. This is especially problematic in engineering fields which require strong math background to successfully navigate through the curriculum in the 4 year expected period.

Additionally, close to 90 percent of the students receive loans and scholarships without which majority of them would not be able to attend the school. Our department records over the past 6 years indicates that at the start of the semester on average more than 54% of our students also work up to 20 hours to cover their expenses. Alarming, over 28% of the students have reported that they work more than 20 hours per week while taking full course load at school.

School has designed many innovative programs to help students improve their math and English skills. However, many of these programs are on a volunteer basis and often students do not take

advantage of them or due to lack of funds, a limited number of students are admitted to those programs.

The OR class has been offered since fall semester of 1990 with the same instructor. It has always been a challenge for students who mostly have lacked the proper pre-requisite knowledge, skill and training for the course. The course had been offered as a traditional course with textbook assignments, quizzes and two or three tests for over a decade. Although, different levels of improvements had taken place with each offering of the course, the average true pass rate of the students in the course never went above 50% and with makeup tests and other bonuses usually 70% of the students passed the course. The real problem, however, lied in the learning deficiencies even among those who passed the course. On the average only 1 out of every 4 student who passed the course demonstrated the deep knowledge gained from the materials discussed. Moreover, students did not demonstrate significant retention of the knowledge through other courses they took after the OR course.

Since early years of the new century, we began incorporating many concepts of engineering education, mostly around the ideas presented in How People Learn^[5] and cognitive learning models into the course design. The new design as explained in Section 1 has brought about many significant positive changes in student performance and deeper knowledge retention.

Enhancement of student learning, increasing active student participation, cooperative and collaborative group learning, development of critical thinking and personal confidence are all beneficial outcomes of an active community of learning. However, it has not resulted in statistically significant improvement in the passing rate of the students in the class. This dilemma has offered a new challenge to investigate further the implementation phase of the course design. Using the concepts of coaching and mentoring is one of the ways we have experimented in response to the challenges mentioned.

The experiment was conducted in fall 2013 semester. The final roster of the class included 39 students, of which 18 were female, 30 African-Americans, with the rest either Caucasians or international students not of African origins. No Hispanic student was in the class.

Section 3: Assessment and Feedback Method

Six different levels of assessment^[6] took place throughout the semester:

1. During lecture, instructor engaged the students in thinking process of why a specific step of a solution methodology was done and what impacts it had on further steps and consequences of not following the prescribed step.
2. During practice presentation, the preparedness of the student and his/her understanding of concepts and procedures were evaluated. This interview type setting with student making the presentation and the instructor listening, asking questions and making suggestions was the most important step of the whole process.
3. During the homework submission stage, readiness of the student to solve a larger problem than a simple practice problem was tested. It was expected that student uses many tools provided for them to master the topic through solving the homework problem.
4. During test, the learning level of students were assessed. Tests require proficiency in dealing with the procedural as well as conceptual issues. Its limited time forces the students to be prepared and know the solution procedure in detail so when he/she begins the procedure, it can be completed without a hitch. At the same time, the test question usually involves some main concepts that students need to use to be more efficient during test's limited time.
5. At the end of the semester student submitted the portfolio of their work for the class. At the minimum, the portfolio was a compilation of all the work student had done in the class including practice presentations, homework assignments and tests for each topic. Additionally each student was required to perform analysis of what they have done wrong in each test that they had not passed and ways to correct them for further topics. Finally, each portfolio had to contain a reflective self-assessment of student's performance in the class and what he/she considers to be a justified grade for that performance in lieu of the class grading policy in the syllabus. Students were also encouraged to include the evidence of their participation in community of learning and their own contributions to the community.
6. Additional feedback was also collected through Google group forum and occasional short participation of the instructor in student initiated study sessions.

Section 4: Mentoring and Coaching Implementation

The innovative method used for the OR class requires students to have a disciplined time-managed approach to their studies. Most students are unaccustomed to the weekly study regiment necessitated by the structure of this class, where falling behind becomes increasingly detrimental to the success, fostering an environment in which an individual student might be overwhelmed with different requirements of the course. Unfortunately, their predicament are not noticed by the instructor until dire consequents are upon them. The innovative method used to teach this class exacerbates this problem.

The exploration into remedies for the mitigation of this problem was the underpinning rationale for this research. Following a policy of continual improvement at the end of each semester, assessments are made based on information gathered through a variety of traditional and nontraditional sources, student surveys, instructor roast, and student portfolios. The idea for the mentorship program came as an outgrowth and expansion of utilization of a teaching assistant who provide tutorial services the previous semester and was well received. Limitation of funding for additional teaching assistants, and the inability to provide adequate time slots for the number of students wishing to use the service prevented the continuation and what would have been the necessary expansion of the service using teaching assistants.

To address this limitation we incorporated and experimented with having peer coaches and mentors to guide and help new students navigate the process. Since, this “falling behind” problem occurs mostly with students who are taking the class for the first time, coaches and mentors become useful resources for new students.

Having produced a community of learning in past iterations of this class offering and having identified a group of students knowledgeable in the conduct of this class; these students were presented the opportunity to be a “coach” or a “mentor”. The responsibilities of a coach and a mentor are listed below:

- **MENTOR:** To be a resource, answer questions, check mentee’s practice and homework before submission.
- **COACH:** To coach 2 students, take them through practice and homework, attend their practice presentation and check their practice and homework to make sure they will pass it successfully.

New students were initially encouraged to use the services of the groups of mentors and coaches on a volunteer basis. In case, a student did not use such services and failed a topic test, he/she was required to work with a mentor or coach for the next topic. Coaches and mentors also attended student initiated study sessions and offered help.

Section 5: Observation, Analysis and Future Plans

Extensive research in education has established the benefits of peer mentoring and coaching to both sides ^[7] and ^[8]. Its implementation in the classroom, however, is not that simple due to students' perceptions of each other and lack of total trust.

The learning outcomes from this innovative method ^[9] have been positive in the areas of content, established a learning environment that augments deeper depth of learning, and establishing students metacognitive approach to problem solving and predicting outcomes. However, assessment through traditional timed structured testing regime that tries to explore if the student has developed a sense of the topic through an organized framework that translates into authentic learning ^[10] has lagged as an indicator of success.

The design of our peer-to-peer mentor and coaching program was meant to directly answer readily observable problems areas. The design of this class fosters an increased workload on both student and teacher, requiring more individualized interaction.

In the beginning of the class, the uniqueness of this method creates observable anxiety resulting in students not passing a practice. In some instances, when the formatting deficiencies are pointed out in the first part of the presentation, students demonstrate a lack of confidence that negatively impacts on the subsequent part of the presentation (see Appendix A).

Having a mentor allows students an opportunity in a low-risk environment to find what they always characterize as 'minor' mistakes. The mentor are trained to emphasize that in a detail oriented class, no mistakes are small; and further, part of the structure is to have students reflect on the importance of following detailed instructions (see appendix A), and the consequence when they don't.

Fostering a community of learners is another benefit of having student mentor/coach. The nature of the class helps to breakdown the habit of isolated study. In this class in particular the

variations on problem solution methods and approaches require active exploration on the part of the students in the so called ‘what if’ scenarios ^[11]. If a student goes through the practice and the individualized homework assignment this is not a guarantee that they have a complete knowledge set of the multiple approaches of that topic or have completely explored them. Thus a student having seen a single solution theme in their practice and homework assignment tends to generalize the myriad of approaches down to the one they studied. By working with a mentor/coach and other students directly or through the mentor/coach, students are exposed to more variations of solution approaches and are less likely to stop exploring other scenarios. Students generally look for clues as to which scenario is most likely to be on a given test which may lead to inadequate preparation. The student fails to develop a schema ^[12] (individual units of memory linked into a system of understanding) around the topic concepts.

In this specific experiment, significant results were obtained in four critical and major areas of concerns. Students demonstrated a much higher rate of retaining the concepts and skills for much longer in comparison to traditional methods. They exhibited a much deeper level of knowledge about the concepts and procedures. In addition, they learned to trust the community of learning and developed a sense of sharing among themselves while exploring new concepts and tools. Finally, they developed strong study skills and critical thinking capabilities that has helped throughout their education.

Three major disappointing results were also noted. It was expected to see significant increase in the faculty load and indeed it happened. There was no surprise there. However, and unfortunately, a statistically significant change in the passing rate of the students was not observed. Upon careful review and analysis of the results, three factors may have contributed to such an outcome.

1. A number of students who did not have a passing midterm grade and were expected to drop the class and they did not. Some of these students stopped attending the class and received a failing grade in the course.
2. Inadequate training of the mentors/coaches
3. Class size which was unusually large (39 students)

We are planning to continue with a new experiment in fall semester of 2014 and to improve the course delivery system we will introduce required training for mentors and coaches and offer the course in two sections.

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Appendix A

Some Guidelines for Practice Presentation and Homework Submission in OR Classes

1. Please remember that all requirements are communicated through Yahoo group. Information that is on the Webpages is general for several classes and may not be related to your specific class.
2. I usually post sample homework problems for topics on my office door. That would give you an example of what you will see as your homework. Practice problem does not need to be similar or the same size, but if the same type of concepts is included, it will be preferable.
3. Get used to EXPLAIN what you have done both in your paper and orally. If I keep asking you questions, it is an indication that you have not covered it in your explanations. If you have to repeat a step 10 times, do not explain it 10 times; one time is enough.
4. Get used to read upside down. You will sit across from me with your paper towards me, going through pages while presenting your practice.
5. All work must be computer processed, but bring your notes and draft pages in case I asked for something that is not included in your report but might be in your notes. An exception is made for the plots; they can be done on engineering graph papers using pen or pencil. **ALL WORK MUST HAVE FOOTERS INDICATING At THE MINIMUM THE PAGE NUMBER** but if you include your name and topic number it would be even better.
6. Cover page and is not necessary for the practice but can be included.
7. When a presentation is not satisfactory, you need to do another presentation with A NEW PROBLEM if you still have time.
8. All your work, including presentations and homework practices and tests are part of your PORTFOLIO to be presented at the end of the class for grade. I do not keep track of your work. Do not lose them. If a work needs to be repeated bring or submit both works.
9. When a practice work is Passed any time after that you may request a homework; simply place your passed homework (and did not passed ones if any for that topic only) in a folder (as explained before) and give it to me. **DO NOT TELL ME** that you like to pick up your homework at any specific time. It may take me about 5 minutes to one hour to process your request. So bring your folder to me when you are actually ready to pick it up.
10. All graded work is placed in the tray on the wall outside my office door. If it is not there, it means it is not graded.
11. All work that you submit must be slid under my office door even if I am in my office and my office door is wide open. **DO NOT GIVE ME YOUR HOMEWORK** in the hallway, classroom, parking lot, etc.
12. **VERY IMPORTANT:** Always manage your time so you would return your homework before 5:00pm. You may find me in my office at 9:00pm and request a homework which I will

probably prepare homework for you. But remember that you do not have 24 hours to do the homework because I may not be in my office at 9:00pm the next day. The time that I pick up the homework the day after that will be your submission time and since that is the past 24 hour deadline, it automatically gets a DNP (Did Not Pass).

13. If you pick up a homework and get a DNP on it, you automatically get a new homework included in your folder **IF THE DEADLINE FOR THE HOMEWORK IS AT LEAST 24 HOURS LATER**. Otherwise, you should concentrate on the next topic. If you pick your assigned homework and somehow cannot finish it within the 24 hour deadline and there is enough time to the topic homework deadline, you may submit your folder with your hand written work to illustrate that you had attempted the work and get a new homework.

14. Practice presentations are not private sessions. They are public events and all who are interested attending may attend someone else practice presentation to reduce the anxiety about it.

15. Always remember: You are only given one deadline the last time the practice is due which automatically puts the homework deadline 24 hours after that and the related topic test the first Monday after that from 9:00 to 10:00am before our class begins.

16. Three DO-NOTs: (1) - Do not remove sample problem from my office door, (2)- Do not look into other people folders, (3) - Do not ask questions about your homework after you have picked them up.

17. Three Dos: (1) - Help others, (2) - Participate in Community of Learning, (3) - Start early.