AC 2010-1392: HOW JUST IN TIME LEARNING SHOULD BECOME THE NORM!

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How Just in Time Learning Should Become the Norm!

Abstract

Many engineering courses present theory and derivations during class time to help demonstrate the beauty of engineering and how mathematics brings clearer understanding of principles. Occasionally some professors even work an in-class problem before assigning students homework to improve their understanding of course content. On closer observation of the students in these classes, a large number of students appear to be bored, day dreaming, or sleeping. It is that the content being presented is not important? Hardly! These students have not been motivated to want to understand the theory behind the many equations that they are using. Most are happy to just plug and chug through their assignments.

How can faculty motivate students to want to learn about the theory behind the equations they use? Just in time learning has been used by the author for a number of years as an insightful way to motivate these same students that other faculty say do not have any passion to learn engineering theory. The author starts most classes with a physical model and then an example problem. As the students become stuck and cannot solve the current problem with the skills developed up to that point, they desire the new tool required to solve the current problem at hand. They are now properly motivated to attack the theory in bite size chunks (just in time) to continue working on solving the problem at hand.

The author has been involved in a number of teaching workshops over the last eleven years and sits in each department faculty member's classes twice each semester and has observed the improvement in student attention, focus, and concept understanding when faculty gradually move to a just in time model. The entire faculty team has observed the improvement in energy levels among the students as well as understanding during the lessons in which just in time learning has been used. The author will start with how just in time learning is applied to a Mechanics of Materials course as well as how the process is being applied throughout a civil engineering curriculum. Course assessment, student feedback, and how just in time learning links to student learning styles will be presented.

1.0 Introduction

What is just in time learning? As defined by Word Spy: "The acquisition of knowledge or skills as they are needed."[1] This definition sums up how many of the students currently in school appear to learn. In fact, first the use of laptop computers and now the use of Apps on phones are pushing this process to be the norm. When the author teaches a freshman Introduction to Engineering course, numerous students search their phones or laptops and provide insightful information to the conversation. Of course, the freshman engineering course is only an introduction and spends a lot of time introducing the history makers that led the charge to changing the world as we know it. How about technical courses?

So how long has this change in student learning been going on? As noted on the Word Spy site as the earliest citation, M. Granger Morgan made the following statement in his

"Accreditation and diversity in engineering education," paper in *Science* on August 31, 1990: "some might experiment with radical departures from conventional curricula such as "just in time learning.""[1] It is now 2010 and a proposed session at the Annual ASEE conference is asking for papers on "just in time learning" best practices. Twenty years… maybe the slow change is tied to the gradual development of technology to support this type of learning. However, even the recent faculty just hired with new PhD's to help build a new program jumped in and began teaching by first presenting the theory and derivations and sometimes getting to an example problem. So maybe it is only the young students who find the process acceptable? Actually many of these same faculty are also using their phones to conduct searches to provide valuable input to discussions within department meetings. Maybe they are just teaching in the mode they were taught in – just emulating their past teachers. The internet lists numerous companies who are turning to the active versus passive style of learning as they provide modules accessible through the company internet sites.[2-4] In fact, the author's cousin who is in human resources development for a large Texas Energy Company for over 20 years notes the continual decrease in actual instructors and that most training is being developed for on-site delivery through the internet as well as providing short face-to-face lessons when the employee is ready for the next step in learning. The entire focus is on "just in time" learning whether using the internet or face-to-face instruction.

Another question that seems to be pertinent is how do students learn best? There is much research and discussion on the topic, but most educators generally agree that students learn best anything that they experience themselves as well as normally do repetitively. Many engineering educators have homework, design projects, and mid-term exams, and many times topics are tested again on a final exam. This process allows the student to first wrestle with the concept at their own pace in a homework assignment where they can collaborate with others before being asked to test their skills within a timed event such as an exam. Learning by doing is the primary basis behind the growth of project-based learning (PBL) opportunities.[5] Some programs have been completely sold on the concept to the point of desiring PBL for all learning activities within the program.[6,7] These collaborative, team design experiences allow even deeper understanding through group work focused on a project. If this process is sound, then why are most instructors just presenting theory rather than having students working example problems where they apply the theory?

A review of the literature on the use of "just in time learning" sheds light on wide array of applications: computer modules[8], web-based modules[9], discussion versus lecture[10], a central course problem that forces new phenomena over the semester[11], supplemental training initiated by students[12], simulations used in class[13], development of links between mathematics and an engineering discipline (e.g., Chemical)[14], providing new content in capstone courses as needed[15], using classroom evaluation to influence what is taught next[16], using mathematical solvers in class[17], integrated programs[18], service learning projects[19], and courses with hands-on-components[20]. None discuss the advantages of using "just in time learning" as the norm for possibly every lesson.

Many workshops including the ExCEEd Teaching Workshop[21] strive to develop student-centered environments through the application of its Model of Instructional Strategy[22] that highlights the need to provide an orientation, stimulate critical thinking, and provide physical models all while considering student's varied learning styles. Upon closer evaluation, even the ExCEEd model is calling for just in time learning. It calls for starting class with a motivator for the subject matter through using a physical model or movie clip and developing an active and engaging classroom environment through questioning techniques which are easily applied during an in-class example problem. Once the students have applied their current skill set and cannot solve the problem at hand, they have been properly stimulated to critically comprehend the ensuing theory ad derivations. So the question is: does just in time learning improve student attention, focus, and concept understanding?

2.0 Mechanics of Materials

The course has the same content seen in similar courses all around the country (Table 1) with topics ranging from axial loaded members, to torsion, to flexural, to buckling, to thin-walled-pressure vessels, to fatigue, to stress concentrations, to stress and strain. The first year (072S) the instructor applied some "just in time learning" and daily homework. When applying "just in time learning", the instructor would start the lesson with an example problem and a physical model representing the problem at hand. As the students worked to solve the problem with their current skills, they would normally get stuck and would call for a new tool derived from theory to help them solve the problem. The instructor chose not to apply the technique often since he would sometimes run out of time when presenting the theory late in the class and feared that the student understanding and skills might suffer.

The author felt that the use of daily homework was a key driver for just in time learning since enough new content must be presented to allow the students to attempt the next assignment. He also noticed that the energy level of the students were much higher and the number and depth of student questions increased during lessons that started with a physical model and example problem that led to the required theory.

Table 1 Course Schedule for Mechanics of Materials

			MENG 3306 Mechanics of Materials 072S	
				AS OF 14 Jan 2008
Lsn	**Study Notes**	**Date**	**Lesson Title**	**Problem Set Due Dates/Notes**
1	MM-1	14-Jan	Internal Forces	
2	MM-2	16-Jan	Normal and Shear Stress	
3	MM-3	18-Jan	Introduction to design	PS 1
		21-Jan	MLK Day	No Class
4	MM-4	23-Jan	Strain	PS 2
5	MM-5	25-Jan	Mechanical Properties of Materials	PS 3
6	MM-6	28-Jan	Lab 1: Simple Tension Test	PS 4
7	MM-7	30-Jan	Stress Transformation I	PS 5

8	MM-8	1-Feb	Stress Transformation II	
9	MM-9	4-Feb	Strain Transformation I	PS 6
10	MM-10	6-Feb	Strain Transformation II	PS 7
11	MM-11	8-Feb	Thin Walled Pressure Vessels	PS 8, Lab 1
12	MM-12	11-Feb	Working Session	PS 9
13	MM-13	13-Feb	Exam 1	
14	MM-14	15-Feb	Fatigue and Stress Concentrations	PS 10
15	MM-15	18-Feb	Axial Deformation I	
16	MM-16	20-Feb	Axial Deformation II	PS 11
17	MM-17	22-Feb	Elastic Torsion I	PS 12
18	MM-18	25-Feb	Elastic Torsion II	PS 13
19	MM-19	27-Feb	Lab 2: Pure TorsionTest	PS 14, EDP 1
20	MM-20	29-Feb	Theories of Failure I	PS 15
21	MM-21	3-Mar	Theories of Failure II	
22	MM-22	5-Mar	Statically Interminate Torsion members	PS 16, Lab 2
23	MM-23	7-Mar	Combined Loading	PS 17, EDP 2
			Spring Leave 10 March - 14 March	
24	MM-24	17-Mar	Working Session	PS 18
25	MM-25	19-Mar	Exam 2	
26	MM-26	21-Mar	Shear and Bending Moment Diagrams I	PS 19
27	MM-27	24-Mar	Shear and Bending Diagrams II	
28	MM-28	26-Mar	Elastic Bending I	PS 20
29	MM-29	28-Mar	Elastic Bending II	PS 21
30	MM-30	31-Mar	Inelastic Bending by Equilibrium	PS 22
31	MM-31	2-Apr	Transverse Shear Stress I	PS 23
32	MM-32	4-Apr	Transverse Shear Stress II	PS 24
33	MM-33	7-Apr	Design of Prismatic Beams I	PS 25
34	MM-34	9-Apr	Design of Prismatic Beams II	PS 26
35	MM-35	11-Apr	Introduction to Beam Deflections	PS 27
36	MM-36	14-Apr	Beam Deflections by Discontinuity Functions	PS 28
37	MM-37	16-Apr	Beam Deflections by Superposition	PS 29, EDP 3
38	MM-38	18-Apr	Working Session	
39	MM-39	21-Apr	Exam 3	
40	MM-40	23-Apr	Lab 3: Bending Test	PS 30
41	MM-41	25-Apr	Combined Loading II	
42	MM-42	28-Apr	Combined Loading III	PS 31
43	MM-43	30-Apr	Column Buckling I	PS 32
44	MM-44	2-May	Column Buckling II	PS33, Lab 3
45	MM-45	5-May	Course Assessment/Summary	PS 34
		7-May	Final Exam 10:15 AM -12:15 PM	

3.0 Results

Based on student comments referencing the need for more in class examples and less boring theory and the continuation of daily homework ("it keeps me engaged"), the instructor tried to conduct all classes with no other course or teaching adjustments than using "just in time learning" as often as possible during the second year (082S). Almost every lesson started with an orientation to the subject matter that included a physical model that naturally led to an example problem. Once the current available tools and problem solving procedures are exhausted, the new theory and associated derivation are presented. Armed with the new equations and associated assumptions (discovered through the derivation), the example problem is completed; thus preparing the students for the daily homework. To vary the learning for students craving a more global learning style beyond the simple presentation of a physical model, lessons with content coverage over two lessons such as elastic torsion (Table 1), the lesson begins with a derivation and the development of the required assumptions.

How was the course perceived by the students who receive much of their teaching up to that point through the traditional methods of theory before application? The best way to respond to the question is through the end-of-semester assessments by the sophomore and junior students taking the course. Figure 1 and Figure 2 display questions that tie directly to the ExCEEd Teaching Model and a Model Instructional Strategy.[21,22] Even though the instructor performance was seen as excellent in 072S (most marks above 4.0 on a 5.0 Likurt scale, n=32 ME and CE students), the performance in 082S as seen by the students was simply outstanding (n=34, mostly CE students). As can been seen, there were a dramatic increases (delta > 0.2 when results are already on the upper end of the scale) in instructor used effective techniques, students contributed to my learning, motivation to learn increased, my critical thinking increased, instructor demonstrated positive expectations, and the instructor helped me understand the importance of course topics. These results were not due to the instructor simply teaching the course for a second time. This instructor had taught Mechanics of Materials seven times before the reported results in these two semesters.

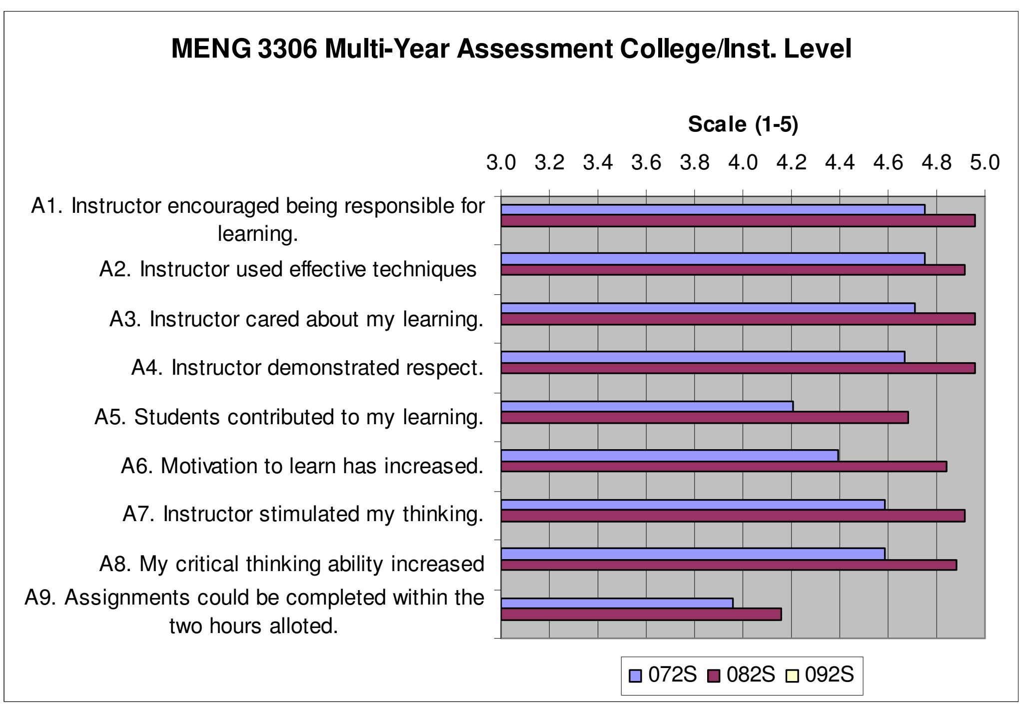

Figure 1 Multi-Year Assessment Institution Level Pedagogy Questions

It should also be noted that the instructor also tries to apply all of the techniques presented within the ExCEEd Teaching Workshop[21] over the last 15 years. In fact the entire department has attended the ExCEEd teaching workshop and the department chair conducts refresher training on key aspects of the workshop prior to each semester as part of exciting the faculty about the upcoming semester. The department is becoming well known on campus for its quality teaching leading some students to make comments within end-of-course assessments that they desired the civil engineering faculty to teach courses within their departments. Therefore, it only seems logical to compare the course results for 082S to the departmental averages for the same semester (Figure 3 and 4). These same results are not seen in other courses taught by the author (Figure 5). In a department full of outstanding teachers effectively using the ExCEEd Teaching Model, could it be the "just in time learning" that is making the difference?

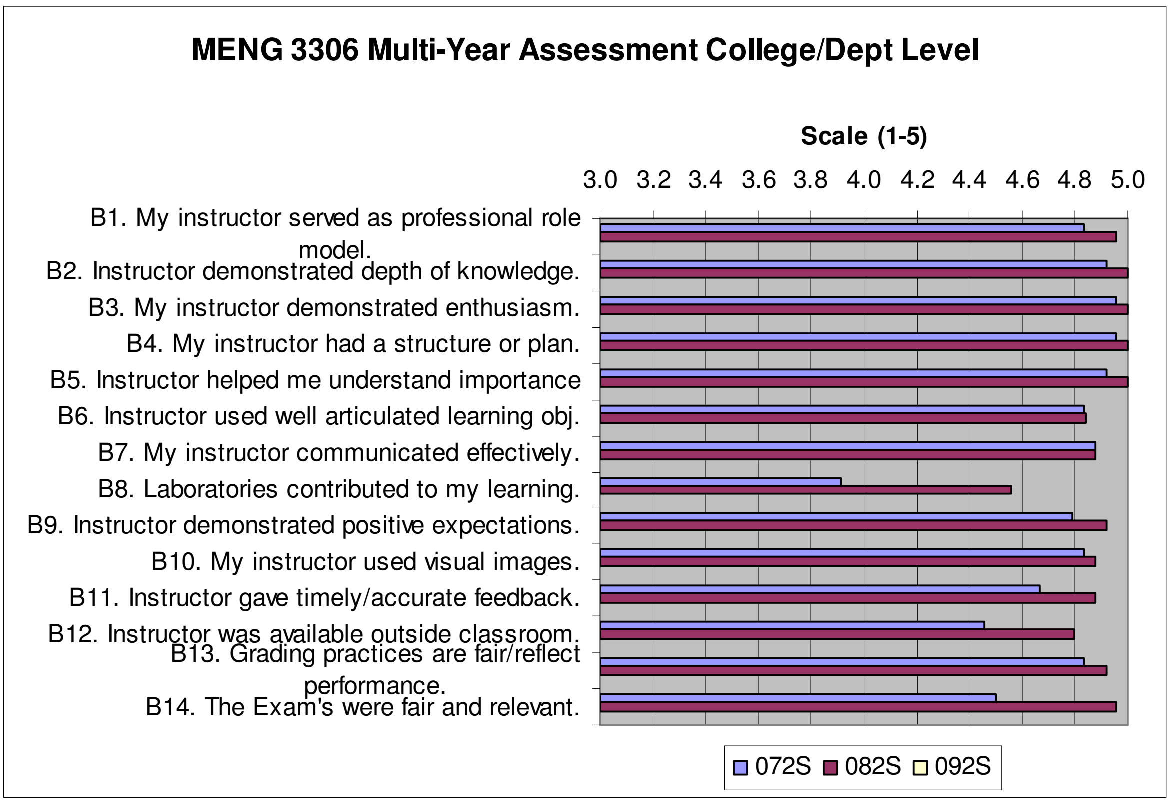

Figure 2 Multi-Year Assessment Department Level Pedagogy Questions

The results presented so far have been based on end-of-semester student assessments (surveys). What about actual technical skills? The department requires every student to take the FE exam. Unfortunately, the results for the 072S group have not been released and the students who took Mechanics of Materials in 082S will take the exam next year. So until then, the internal (FE Like) gateway exam developed by the department provides some glimpse into the skill set of these students. The author was hoping for a dramatic increase based on the end-of-course results. However, the results were basically the same for each group (59 percent (072S) to 57 percent (082S) correct for the FE like questions, while the number of students in the CE program nearly doubled from 072S to 082S. At least the results did not dramatically decease based on not starting with theory before example problems. The same can be said for the student's assessment of their understanding of course objectives which remained practically even (Figure 6 and 7) with some increases and some decreases, but the amount of change was basically small.

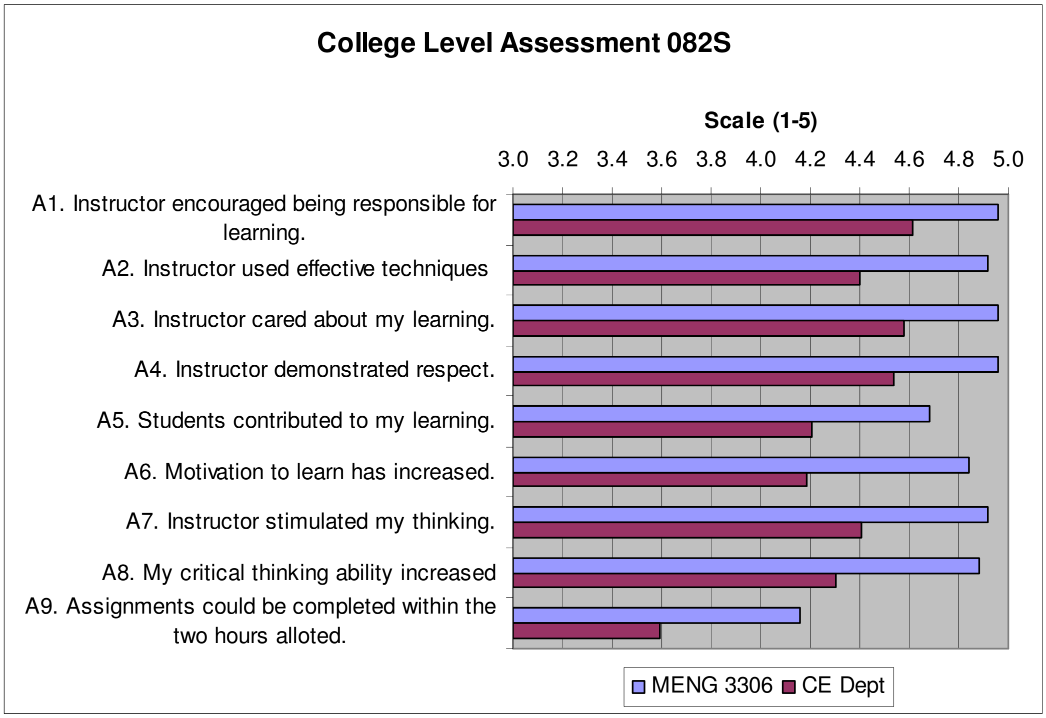

Figure 3 082S Assessment Institution Level Pedagogy Questions

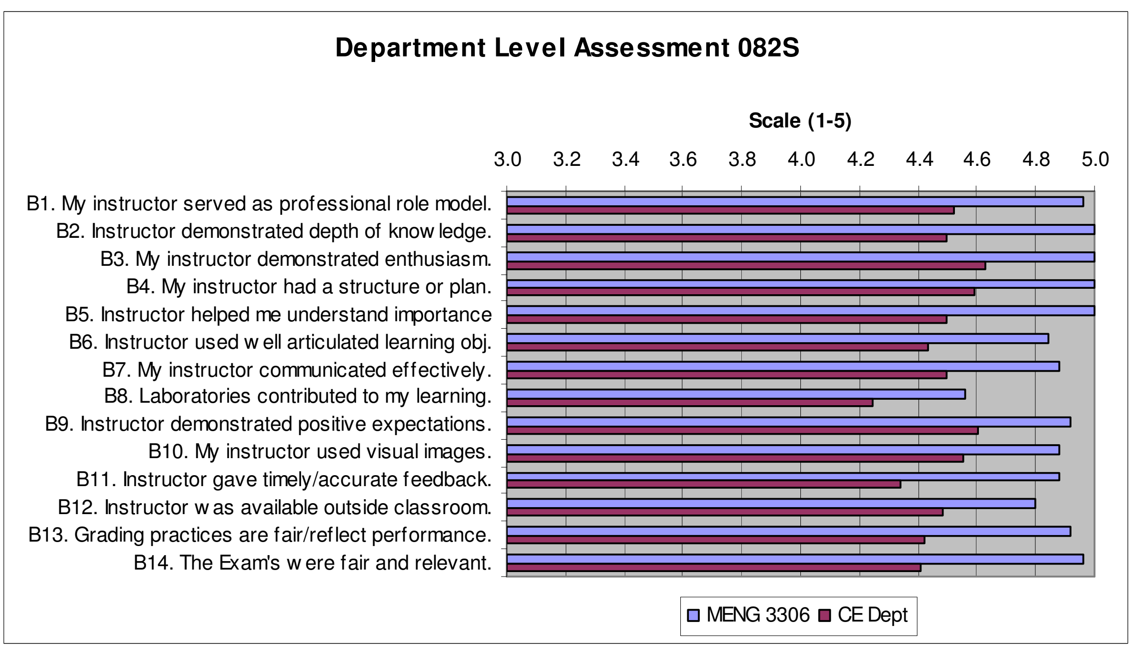

Figure 4 082S Assessment Department Level Pedagogy Questions

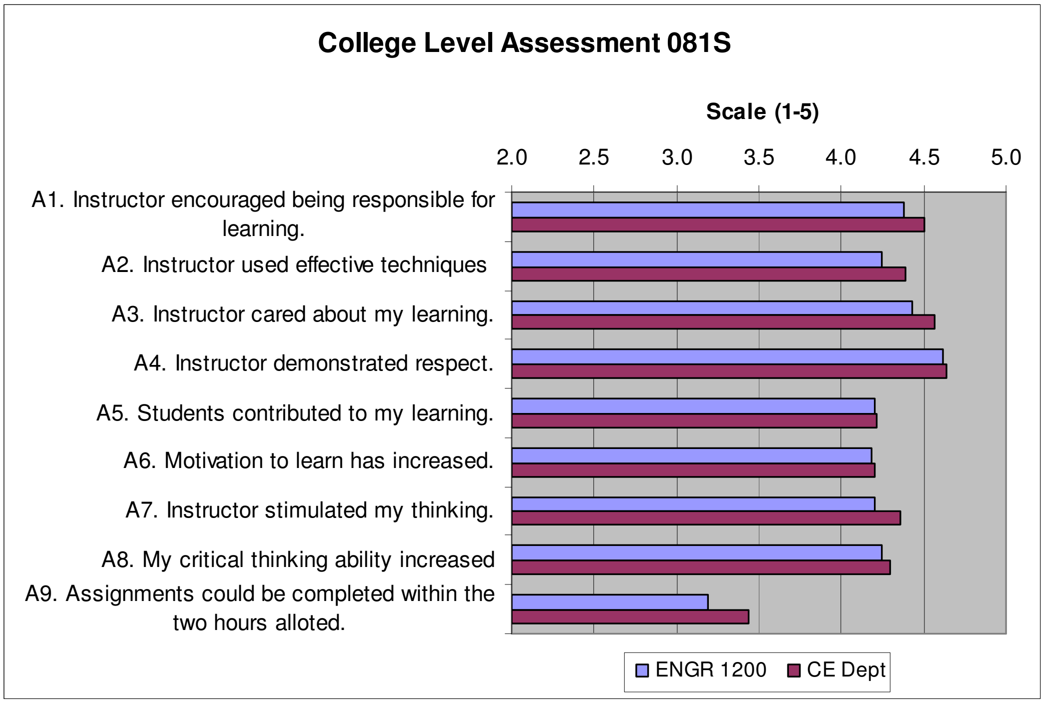

Figure 5 081S Assessment Institution Level Questions

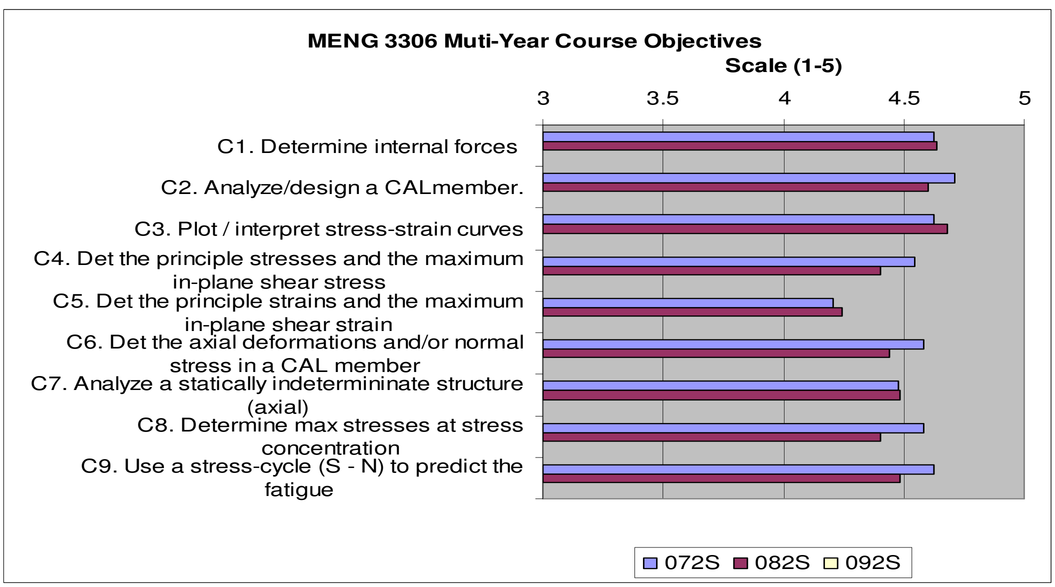

Figure 6 Multi-Year Assessment of Course Objectives

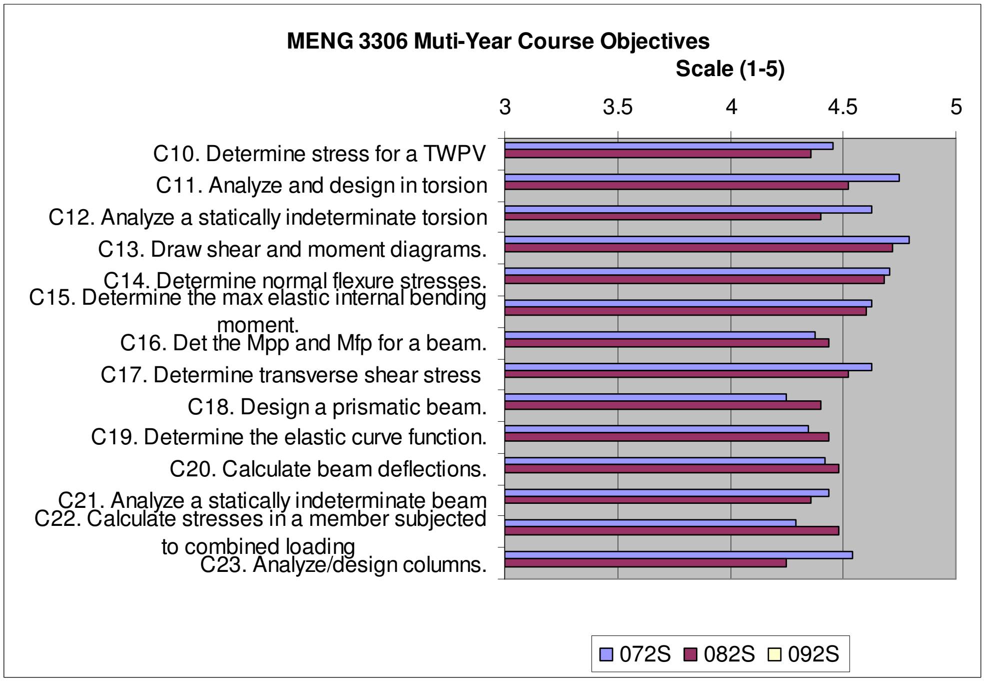

Figure 7 Multi-Year Assessment of Course Objectives

The results from this coming spring will be added to these tables and presented at the annual conference to include the internal gateway exam results. These results have resulted in a number of the civil engineering faculty to begin using "just in time learning" within their classrooms as well. They are beginning to experience modest, yet similar results. However, the change in classroom atmosphere is the most dramatic effect that enhances the teaching experience for the faculty and makes teaching fun and exciting. Just in time learning lines up well with changes to Felder's work[23] that all teaching should be inductive – learn through current experience such as starting with an example problem to derive the need for theory. The in-class example meets the needs of the active and sequential learners, while the theory meets the needs of the reflective and global learner (note that the physical models help meet the needs of the global learner as well). This study will continue with longer term results presented in the future.

4.0 Conclusions

The students appear to enjoy "just in time learning" better than presentation of traditional theory before applying the theory within practice problems if time permits. The learning becomes more active and the instructor received dramatic increases in instructor used effective techniques, students contributed to my learning, motivation to learn increased, my critical thinking increased, instructor demonstrated positive expectations, and the instructor helped me understand the importance of course topics. Of course, improvement in technical content still awaits the FE results in out years and this coming spring's internal gateway results. Preliminary results show slight decrease in technical capability which is the argument of those against "just in time learning," but this is only considering two data sets for now as well as the limited number of questions covering mechanics of materials on either the FE or departmental Gateway exam. .

If the student is more interested in the topics at hand and gains confidence that they can learn new topics as needed through the experiences within the classroom, they may be better prepared for the work force than traditionally taught students. A review of how company's train employees as noted by the author's cousin shows a transition to "just in time learning." Companies train as needed rather than spend months training an employee who may not even work out and need to use many of the skills they have been trained for prior to working in any real capacity for the company. Just in time learning trains future engineers to not be afraid of new problems just because they have not seen it before, but rather they should be able to attack the problem and search out paths to provide solutions they need.

4.0 References

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