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INNOVATIVE APPROACHES AND LESSON LEARNED IN TEACHING CAD/CAE APPLICATIONS COURSE

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ABSTRACT

The application of Computer Aided Design and Engineering has been very popular in the engineering industry recently due to its usefulness in significantly reducing the time-to-market and cost involved within the design lifecycle of an engineering product. Despite the extensive availability of step-by-step manuals and tutorials to learn such tools, the emphasis of synergic utilization of such tools within the engineering design process has not been effectively addressed. Students often pay attention to learn how *to use the tools instead of* why *to use such tools. In this paper, we present an innovative engineering education framework with various collaborative and interactive in-class activities and Web 2.0 tools to address the above issues in a senior undergraduate/graduate level CAD/CAE Applications course offered in University at Buffalo. Specifically, we categorize the approaches based the following components: (a) traditional lecture and computer labs, (b) team-based projects, (c) in-class activities, and (d) online course management tools. We show how the proposed approaches can be merged to the existing course syllabus in a synergic manner based on our experience. We also describe the rationale of the approaches and the expected outcome/improvements.*

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1 INTRODUCTION

The application of Computer Aided Design and Engineering has been very popular in the engineering industry recently due to its usefulness in significantly reducing the time-to-market and cost involved within the design lifecycle of an engineering product. Referring to Fig. 1, Computer Aided Design (CAD) refers to the software environment that permits engineers to create geometric entities in the form of *parts*, and establish the constraints between the entities to form the *assemblies*. Computer Aided Engineering (CAE), on the other hand, refers to the software environment that allows engineers to *analyze* the geometric entities by integrating the physical properties and features to the parts or assemblies created in the CAD packages. Such CAE packages often employ finite-element-based computation to permit analysis for complex geometric entities. Often, such CAD/CAE packages are shipped in the form of the Product Lifecycle Management (PLM) solution developed by various vendors. For instance, the course described in this paper employed Pro/ENGINEER as the CAD package and Pro/MECHANICA as the CAE package, which are developed by Parametric Technology Corporation (PTC)[1]. The integration of such CAE software into the PLM packages clearly revolutionized the way engineers quickly study the feasibility of various designs virtually prior

[1]Some other examples include Solid Works with COSMOS. However, the paper attempts not to enumerate the packages available in the market to emphasize that the students should not pay attention to only a single software, but should be able to leverage themselves to other packages easily.

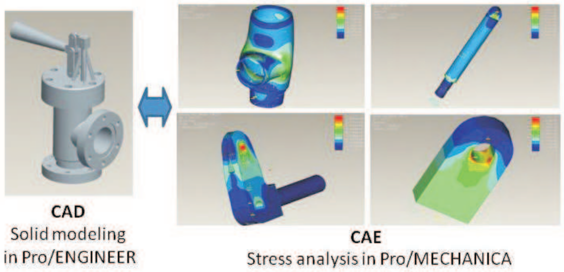


FIGURE 1. CAD and CAE

building/testing the expensive physical prototypes [1, 2].

Despite the extensive availability of step-by-step manuals and tutorials [3] to learn such tools, the emphasis of synergic utilization of such tools within the engineering design process has generally not been effectively addressed. Students often paid attention to learn how to use the tools instead of why to use such tools[2]. Furthermore, many CAD courses have been emphasizing on how to use a particular software, which made students often finding it hard to change from one software to another. In fact, the computation algorithms behind a lot of the CAD/CAE software in the market employed very similar *physics* and *first principles*, but the differences only come from the user interface (UI) of the software. Hence, it is important to encourage the students to understand such general principles. Once the students have a good grasp of these foundation, it will be easier to leverage their CAD/CAE skills to any of the different software from the other vendors. *The key point is that the engineers should be able to distinguish themselves from the CAD operators - the CAD operators emphasize on the UI aspect of the software, but the engineers should understand how the software works and how it can perform better to aid their design iterations*.

There has also been extensive literature reporting CAD-related education. Ye et. al. [4] performed an extensive questionnaire-based survey through the employees in a number of large CAD developers on the components that the future successful CAD engineers should learn. The opinions reported were somewhat random, but there was consensus agreeing that mathematical and mechanical background are rather important in making effective use of CAD software. García et. al. [5] on the other hand created their own CAD package to "control" what the students needed to learn from a CAD course. Such approach may not be favorable since the students might not be able to leverage their skills in other platform. In addition, most of the reported CAD-based education were based on the geometrical (and/or artistic) modeling with little emphasis on the physical feasibility [6–8]. Cheng [7] suggested that CAD should be learned in the "language learning" sense, where the geometry should be "natural" to the students. Our approach is similar in the sense that we required the students being able to develop engineering judgment in the physical sense in the scaffolded manner. Lin et. al. [9] presented *an* approach to teach CAD/CAM, claiming that the approach fulfill the ABET requirements. A lot of these approaches are still in the context of CAD (with exception of [9]), none of the above work proposed innovative approaches to take into account the CAE-based physical analysis. While training is an important part of learning CAD/CAE [10], we strongly believe that combining some of the non-traditional methods in addition to training can effectively improve the students' learning experience.

This paper reports the authors' teaching experience and lesson learned at University at Buffalo in Spring 2008 semester. The course *MAE477/577 - CAD Applications* is a cross-listed senior undergraduate/graduate level course offered by Department of Mechanical and Aerospace Engineering at University at Buffalo. The major scope of the course is to equip the mechanical and aerospace engineering students with the general framework of implementing CAD/CAE in the design, analysis and optimization practices for mechanical designs through a balance between the theory and its application. Specifically, the course provides the bridge between the basic courses in statics, mechanics and machine design to practical engineering problems through adequate CAD solid modeling and accurate CAE analysis as well as the validation process through analytic solutions. Perhaps, the most important point is to critically challenge the solutions from the CAE tools and propose optimized designs and develop confidence in effective utilization of such tools from simple to complex engineering problems. The course is the final phase over the entire undergraduate curriculum of the series of CAD courses [11]. Throughout the curriculum, the students are exposed to two major CAD software, namely AutoCAD (for 2D-based drafting system) and Pro/ENGINEER (for 3D-based parametric solid modeler). These experiences well prepared the students to gained deeper understanding on the CAD/CAE tools that they are about to study in MAE477/577.

In this paper, we present an innovative engineering education framework integrating various collaborative and interactive in-class activities and Web 2.0 tools to address the above issues in a senior undergraduate/graduate level CAD/CAE Applications course. We categorize the approaches based the following components: (a) traditional lecture and computer labs, (b) team-based projects, (c) in-class activities, and (d) online course management tools. *Traditional lectures and computer labs* emphasize the linkage between the computational tools and the theoretical framework to the development of the engineering judgment and "intuition" to the students. *Team-based projects* require the students practically apply the engineering design process in one-month project. The students were required to propose a system, formulate the related problems, decompose the problems into smaller task, propose alternative improvements, and solve the problems in the group consensus manner. *In-class*

[2]This is the general observation by the authors over years of CAD/CAE training experience in the research lab and prior educational work reported in [1, 2].

activities include: (a) innovative game-based competitions, (b) brain-storming sessions on specific CAD/CAE topics, and (c) visualization lab visits. Based on the authors experience, these activities have been shown effective in enhancing the students' understanding on course materials. *Online course management tools* such as Blackboard was extensively used to: (a) post lecture notes, assignments and multimedia to enhance students' learning experiences, (b) manage logistics using e-mail interactions, and, more innovatively, (c) enhance interactions through forum-based discussion board. Ultimately, such tool minimizes the need of the instructor, the TA, and the students to meet together other than the lecture hours.

While many of the above approaches may not be new in the engineering education community, the contribution of this paper, however, is to show how the proposed approaches can be merged to the existing course syllabus in the synergic manner based on our experience. We also describe the rationale of the approaches and the expected outcome/improvements. The reported experience can also be adopted by many CAD/CAE courses available in many universities, and this paper can serve as a *lesson learned* to encourage other instructors, who are hunting for ideas and/or teaching method modification to their course, to adopt in their own courses.

2 TRADITIONAL LECTURE AND COMPUTER LAB

The course was run in the form of three 50-minute lectures and one 2-hour lab session per week. In general, the lecture covers the general theory and practice in using CAD/CAE system, while the lab reinforces such theories by hands-on implementation through exercises. We used the commercially available CAD package Pro/ENGINEER Wildfire 3.0 with the CAE package Pro/ENGINEER MECHANICA. The textbook for the theory was Lee [12] while the book by Toogood [3] served as a supplement tutorial.

The *lecture* was broken down into three major theoretical topics, namely: (a) CAD modeling and 3D visualization, (b) finite element method (FEM), and (c) optimization and sensitivity analysis. They were taught in the *theory for practitioner* manner without very deep theoretical exploration since each of the above topic deserves a full semester course. The topic *CAD modeling and 3D visualization* introduced the 2D and 3D representation, manipulation and transformation of solid objects in computer graphics, including translations, rotations, projections, curves/surface representation and solid model constructions. The major emphasis was to make the students understand and aware of *every mouse click they performed in CAD*. More advanced topic like free-form curve/surface that the students were not taught in the previous CAD courses was also introduced so that they know how to model and parameterize more complicated shapes in CAD. We then established CAE foundation by the introduction of *Finite Element Method* (FEM). We introduced principles of FEM for solid structures, which included fundamental topics like nodes, elements, degree-of-freedom, stiffness matrix, mesh and shape functions. This topic is very important and deserves more elaboration in the subsequent subsection. Finally, since CAD/CAE tools are fundamentally used in a *design process*, the introduction of the fundamental concepts on *optimization and sensitivity analysis* can be very useful in the course. We introduced concepts such as design variable identification, objective function, constraint modeling, 1- and n-dimensional steepest-decent search for unconstrained and constrained problems, which were sufficient to allow the students to explore the optimization features available in the CAE package.

In the *lab*, we used Pro/ENGINEER Wildfire since it is interactive and parametric. It also comes with the optional CAE tools called Pro/MECHANICA, which provides a series of modules that allow engineers to perform a wide variety of engineering analysis in the finite element sense. In this course, we emphasized the Structure Module to perform solid mechanics analysis. The lab was mainly run by the Teaching Assistant (TA) in the form of step-by-step training. We suggested the students to purchase the very cost effective lab manual by Toogood [3] so that they could either learn the user interface at their own pace or review and recap the operation as needed.

In what follows, we identified 3 major aspects of FEM that should be kept in mind when teaching such CAD/CAE application course. These issues are often not properly summarized and addressed in the standard textbooks, and this list should be very useful to instructors that do not have good answers for the following questions to the students.

2.1 Solutions from FEM are approximations

It is important to understand that Finite Element Method (FEM) is a numerical method for *approximating* the governing (partial) differential equations of a continuous system to satisfy some specified boundary conditions. The main point that is always forgotten is that the solution given by the FEM-based CAE software is only an *approximation*. FEM is extremely problem dependent, and there is no single FEM application that can be universal to any engineering problem. Indeed, it could be observed that most students thought that CAE is a universal solution to any engineering analysis, and some even believe that they should not "waste time" in studying other engineering analysis courses, but just to use CAE to solve any of the engineering problem. In order to minimize the error of approximation, it relies on how well the engineers (a) understand the engineering problem in hand, (b) understand the limitation of the software, (c) use the appropriate FEM settings, and (d) set the appropriate parameters for the FEM. Without the careful use of the software, it could easily end up with the "garbage-in-garbage-out" situation.

We begin by illustrating some background material. *Direct method* is often applied in most CAE packages, where the "solution field" of the (partial) differential equations (PDE) is approximated directly using polynomials based on the defined boundary conditions. The procedure of FEM can generally be described as follows:

1. Discretizing the continuous domain into elements;
2. Selecting shape functions to approximate field variables of the elements;
3. Determining the element properties based on the geometry and material properties;
4. Assembling the element properties to form full system properties;
5. Solving the (linear) system equations to determine the unknowns.

Hence, in the case of structural analysis, given a large solid, we first discretize the entire domain into meshes. This means that the overall PDE is discretized into smaller pieces, and the solution of each piece is determined by the standard shape functions. In the final count it is hoped that these pieces of solutions to build the solution of the entire domain. This depends crucially on Step 1 and 2 in the above procedure. In general, there are two types of *elements* employed to address these steps, namely *h*-element and *p*-element. Referring to the 1D illustration in Fig. 2, the solution is approximated by first order elements when using the *h*-element. In order to reduce the error between the "correct" and the "approximated" solutions, we can reduce the size of *h* so that all the horizontal lines almost matching the solution. However, reducing the size of *h* means increasing the computation significantly. Furthermore, the solution is fundamentally discontinuous which prohibits the evaluation of some other functions that require the derivative/integration of the solution - see [13] for elaboration. Therefore, the "smarter" approach would be using the *p*-element, where the solution is approximated by piecewise continuous polynomials with (relatively) larger element size. The order of the polynomial is then increased to "conform" to the solution, and the derivative/integration of this solution can still be continuous. However, it is well-known that if the order of the polynomial is chosen to be too high, oscillation near the boundary condition can occur, which can again produce inaccurate solution [14]. Hence, in standard CAE packages, where the engineer has the freedom to choose both the mesh size and the order of the mesh solution, unless these parameters are traded off properly, it would produce undesirable solution[3].

2.2 Solution verification

While the "approximation" issue has been address, it is then important to verify that the solutions are within the acceptable

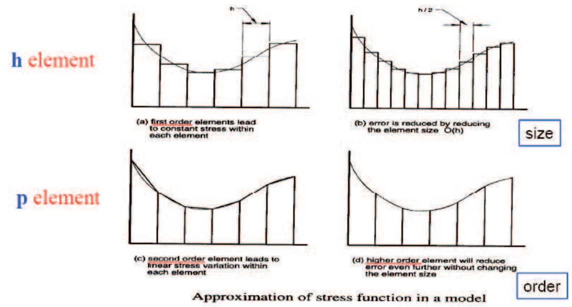


FIGURE 2. *h*-element and *p*-element

tolerance. Hence, the question that the students often asked was the following:

> *We do not even know the correct solution, so how could we even know if the solution is correct?*

The way to account for this problem is to employ the physical fact that:

> *The strain (potential) energy of a static mechanical system under loadings should conserve.*

This means that when the mesh is coarser, there is strain energy "left out" from the system. The refinement of mesh can then "include" more strain energy to the system. However, since the strain energy should conserve within the system, the refinement increase of mesh should see convergence in strain energy, i.e. more improvement of the solution could not be achieved even the mesh is further refined. Hence, it is always important to evaluate the *strain (potential) energy* over the increasing of *h* and *p* to see if the profile is converging [3,15] - see Fig. 3. When the order of the *h*-element is increasing, the strain energy of the entire solid should be converging to a value. Otherwise, different size of the mesh or the type of the mesh (varying *p* of shape function) should be tried for the problem. It is also important to note that despite the solution (such as von Mises stress) is converging, the strain energy might not converge. Hence, the convergence of the solution does not guarantee the accuracy of the solution [15]. Most modern CAE software provides tools to automate this process, and it is important for the user to employ the tools to evaluate and verify their solutions.

2.3 "Large-scale" problem

Another major issue that often encountered by the authors was one of the issues mentioned in the previous section. They often complain that:

> *My simulation takes forever, what should I do?*

This was the very common mistake for the students who solve engineering problems by the approach of "just plugging the num-

[3]In fact, in [3], the author successfully motivated the use of *p*-element but (almost) carelessly noted that higher order should always be used - which is misleading. In some cases, both the sizes and the orders of the meshes should be properly trade-off to produce optimal results.

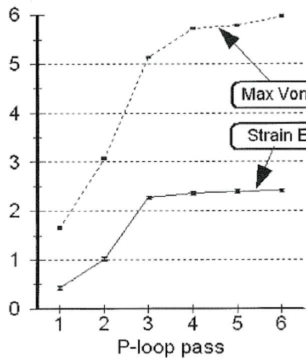


FIGURE 3. When the order of the *p*-element is increasing, the strain energy of the entire solid should be converging to a value. Otherwise, different size of the mesh or the type of mesh should be tried for this problem [3, 15].

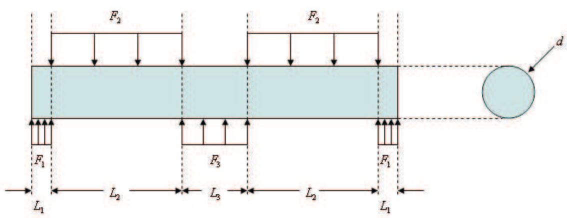


FIGURE 4. An example beam problem in mini-project for "benchmarking"

bers into the formula". They expected the CAE tools are universal enough to solve anything that they can construct in a CAD software. They often started out by creating very complicated CAD models, exported them to the CAE module without a second thought, and hoped that "pretty pictures" could display after a single click of a button. This approach is clearly not feasible and not the way an *engineer* solving a problem. Often this happened to students who did not spend enough hours practicing with smaller examples, such as a simple beam. To attack this issue, we created a mini-project to emphasize the *benchmarking* of the CAE software, so that the students could understand what the software can/cannot do, and what it can do the best.

We assigned the problem shown in Fig. 4, where, for $i = 1,2,3$, F_i are evenly distributed forces, L_i are lengths, and d is the diameter of the beam. We asked the students to first obtain the analytical solution of the problem. We then asked them to explore and trade-off the accuracy and computational time: (a) over the 1D simplification or full 3D computation; and (b) by taking advantage of the *symmetrical geometry* of the system. The specific problems were as follows:

1. Show that the shaft is in the equilibrium state using static analysis by hand-calculation;
2. Construct the beam deformation, shear force and bending moment diagrams analytically;
3. Using the idealized (1D) "beam element" model, plot the beam deformation, shear force and bending moment diagrams;
4. Taking the advantage of the symmetry of the problem, applying appropriate boundary condition, plot the beam deformation, shear force and bending moment diagrams;
5. Analyzing the shaft using the "full 3D model", plot the fringe plots of von Mises stress and deformation distributions;
6. Again, taking the advantage of the symmetry of the problem, applying appropriate boundary condition, plot the fringe plots of von Mises stress and deformation distributions;

TABLE 1. Example beam analysis results

Model	Max Shear (MPa)	Max von Mises Stress (MPa)	Max Displacement (m)	Process Time (s)	Comments
Analytical (Hand Calculations)	15.00	1.70	0.003458	N/A	Fair Accuracy + Slow
Idealized Beam	15.00	1.86	0.000707	0.27	Fair Accuracy + Fast
Simplified Idealized Beam	-15.00	2.75	0.003414	0.25	Fair Accuracy + Extremely Fast
Full 3D	14.55	29.04	0.010940	603.97	Best Accuracy + Extremely Slow
Simplified Full 3D	31.50	60.34	0.052667	328.41	Poor Accuracy + Slow

They were required to note all the computational time elapsed, maximum deformation, maximum shear stress and maximum von Mises stress for critical comparison. A typical example solution is shown in Table 1. This analysis effectively encouraged the students to understand the capability of the software before carrying out a "large-scale" problem. In fact, the tutorial [3] also illustrated many other ideas to prevent the above problem, including smoothening the edges for better mesh generation, etc. The difference here in this project was to critically compare and challenge some of the statements made in [3].

3 TEAM-BASED PROJECTS

While both *team-based* and *project-based* learning are not new approaches in engineering education, the synergic merge between these two approaches is relatively young. In most approaches, the instructor allows the students to form teams of 2 to 3 persons, and define a project so that it can be finished by the end of semester. Some times to prevent imbalance performance within the group (to prevent all well-performing students or weak-performing student in groups), the instructor takes the role in forming the groups. The specific project topics are even assigned in some cases to ease the grading. In this course, however, we allowed the students to form their own groups. We believed that the students who know each other well can learn better from each other. In some cases, the members were already working together in a group for projects in some other courses, so it would be much more effective in project execution since they could spend less effort in finding the common time and place to meet, but focused more on the project execution itself. In some cases, we also encouraged undergraduates students to work with graduate students. This could also effectively encourage undergraduate students to explore the "research" nature of the problems. Finally, the students were also encouraged to use Yahoo/Google Groups [16, 17] or PBwiki (now PBworks [18]) to manage their projects in an effective manner. Throughout the course, we assigned multiple mini group projects with predefined projects and a final project.

In the final project, we left the topic as open as possible. We asked the students to submit a proposal in the 6th week of the semester. This allowed them to have some times to define the project of their interest. The proposal was considered the Phase 1 of the final project. Then, they were be asked to submit the Phase 2 of the final project in about 8th week, which showed that they had constructed a number of parts of the system that they were interested to study. We also required the group leaders or any group member to prepare a 2-minute presentation for one of the lecture hours in the same week. Since the given time was short, the presentations were expected to be as concise as possible, i.e. a small description to describe the project without going too much into details was expected. The point was just to put a figure or two to describe the project without too much wordings in the slides. This is an important skill as a lot of business presentations expect concise and straight-to-the-point presentation of preliminary product ideas, and this presentation highlighted this notion.

In the final week, the class was able to produced 19 outstanding projects[4] that are illustrated in Fig. 5. It turned out that bi/tri-cycle systems were the most popular subject of study. Other interesting project included an ice-cream maker and a sailboat. Some even able to integrate with projects for other course, such as Design Theory, where the notion of "Design of Experiment" was employed to minimize the number of analysis for complicated truss system.

We used the final exam hours (a 3-hour time frame) to allow the students to showcase their projects in the form of 10-minute

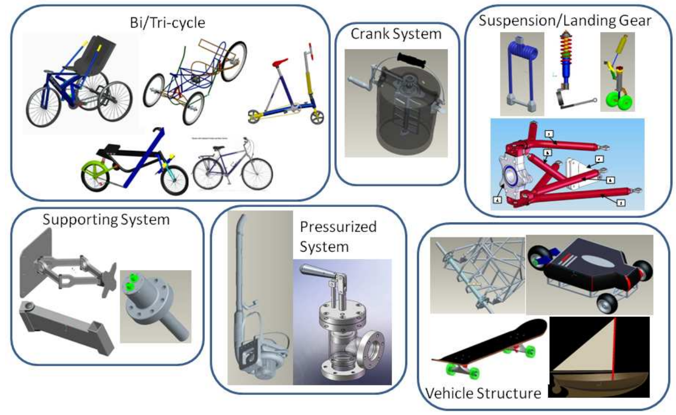


FIGURE 5. The gallery of the students' work in the Final Project.

presentations. During the presentation, the projects were judged in 3 aspects. First, there were 3 professional judges form by outside PhD candidates and research associate. They generally judged the Technical Competence, Implementation Details and Presentation of the project. Second, they were also judged by the other groups by rating (1 to 5) based on the following quick questions:

1. Is the presentation concise yet informative?
2. Does the project sound technical (without judging the style of the presentation)?
3. Were the problems well-organized and solved?
4. What is your overall impression to the project?

We believed that the students should also be in the position to critique the work by other groups. Although this was not weighted heavily in the final grade, this was at least to force the students to pay attention to learn from the others. Finally, they were also judged by their own group members through providing comments. These comments were held confidential so that they could be as honest as possible, which would be very easily to identify the students who were not actively participating in the project execution.

4 IN-CLASS ACTIVITIES

One of the major goals to introduce in-class activities was to maintain a good attendance rate and, potentially, induced better learning of the theory more than just using the class notes. We could see that most of the students were able to catch up with the understanding of the materials, and were also able to apply them through the implementation of the projects. It has also been shown that most students could learn fundamental concepts more successfully, and were better able to apply them in real life examples through interactive and collaborative learning. Hence, the approaches introduced in this class geared towards this goals.

[4]All the projects submitted showed that the students were able to apply correctly all the materials learned throughout the course in very practical projects. They fulfilled both the requirements and high level creativity.

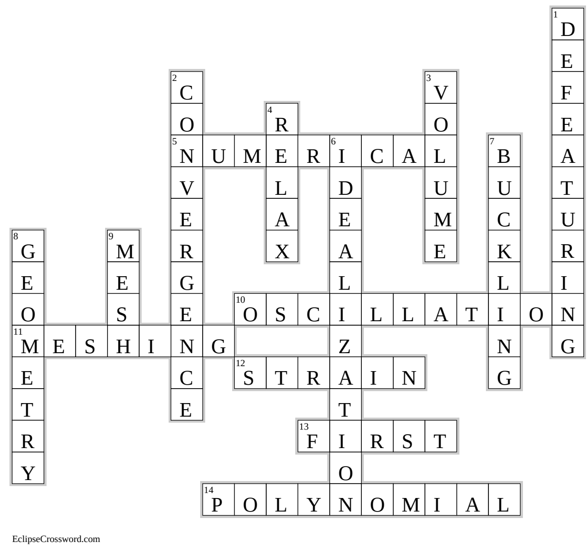
4.1 Group Discussions and Games

Group discussions and games can be very interactive activities that could be carried out in the class to promote active learning. Instructors often find that it is hard to prepare either a good topic of group discussions, or a properly organized games due to the large class size or short lecture hours. Hence, these approaches were always ignored. In fact, it is normally not hard to find opportunities to work on these approaches. The time taken to prepare the lecture could as well be approximately the same as the time taken to prepare for these discussions and games. In fact, not only the students could learn fast, but also could make sure their brains were active to think, and the instructors could also learn something from the new generation, i.e. mutual learning through interactions. It is often useful to exchange ideas through interactions. Not only the students could learn from the ice-breaking sessions, but discussion could be also promoted and lead to the ideas that were never thought before.

It is important to note that lecture solely could be dull, and the students could probably only absorb limited amount of information in a lecture. Hence, it could be more useful to explore more effective learning method to avoid the above problem. Instead of packing all the materials into the students minds, some important points should be emphasized on (for instance, the materials mentioned above) and they could learn through games and discussions. The students can often remember better through these activities.

To present an example, one of the situation that the author found out was the students' ability to remember some of the important terminologies in the CAD/CAE context. Hence, in one of the games, we gave each of the students a crossword test. Such crosswords could be easily made by an online service called the Eclipse Crosswords [19]. The user just has to key in the keywords, and the online service can output a crosswords based on the keywords provided. They can be output as a Word file for easy adaptation for the class. This approach not only inspired them, but also made them think in terms of the keywords so that they could better relate the terminologies and the clues. We found that most of the students were able to fill in the blanks without problem.

We also gave them some magazine articles [13, 15] written by the professional engineers that critically discussed the issues in using FEM-based CAE software in real engineering examples. This is important since the author argued a lot of the practical points from the industrial perspectives instead of the university-based theoretical research perspectives. This often effectively motivated the students, who wanted to contribute to the industry, to learn that these are indeed very *practical theories*. Since there were some students from the industry who were taking the course part-time, we asked them to share about their job functions in the class so that the students could better appreciate the importance of the materials learned in the course.



(a) The crossword

Across

5. Mathematical model is solved by ________ method in finite element software.
10. When the order of polynomial is too high, it might induce ___________.
11. A process of splitting a continuous model to discretized pieces.
12. In structural FEM, the formulation is based on minimization of ________ energy of the closed system.
13. If using only ______-order elements in approximating field variable of interest in an FEM model, the solution would be piecewise linear.
14. Field variables in p-element can be described by higher order __________.

Down

1. Elimination of small and unimportant details in a finite element model.
2. Any FEM result should be produced by a __________ process rather than by a single solution.
3. Automesher are fast and easy to use, but they normally purely a process of filling up a given ________ in a 3D model without considering the field variable of interest.
4. One of the ways to reduce modeling error is to gradually _________ restrictive simplifying modeling assumptions.
6. A process of simplifying the physical world during finite element analysis.
7. ___________ is often ignored in mathematical model in a long or curved beam.
8. Mesh should be able to adequately represent __________ and have the capability of properly model displacement and stress pattern.
9. Degrees of freedom increases while number of _________ increases.

(b) The crossword hint

FIGURE 6. The crossword with all FEM terms, created by Eclipse Crossword [19]

4.2 Lab Visit

The authors felt that by allowing the students to visit a high technology research center could encourage the students to explore the vast possibilities of CAD/CAE application, which is not just focusing on the PC-based analysis. NYSCEDII (New York State Center for Engineering Design and Industrial Innovation) is a large research center at UB, and possesses state-of-the-art visual reality hardware facility for immersive and high-end visualization of CAD/CAE models (see Fig. 7). The authors were fortunate to invite the Senior Research Associate, Dr. Kevin Hulme, who is an expert in computer visualization to give an overview of the facility, and to present the connection of the use of CAD/CAE tools to the lab's activities. The specific example were the use of CAD to create the 3D models and display

FIGURE 7. NYSCEDII's virtual reality hardware facility for immersive and high-end visualization.

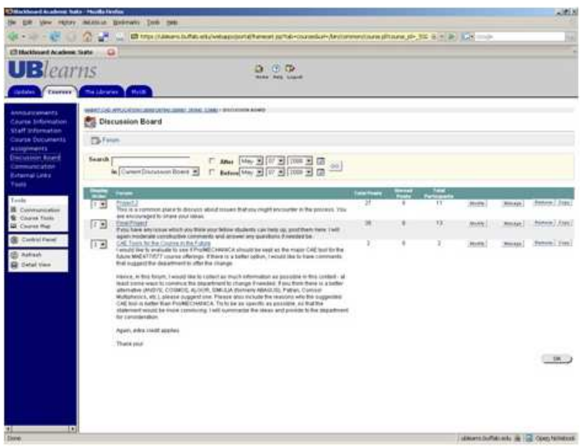


FIGURE 8. UBLearns Page

on the screen to improve the user's perception during the vehicle simulation process. Not only the geometric entities for the visualization is important, but also the inclusion of the physics to these entities that made them useful [20].

5 ONLINE COURSE MANAGEMENT TOOLS

BlackBoard provides a very efficient online tool to manage the class information so that the students can access the materials easily as long as they have internet access. UB implements this system and called it the *UBLearns* [21] - see Fig. 8. The major point of using this mechanism was to build interactivity between the students and the instructor (and TA) even though they were not meeting in the common place. The major functionalities used was for the following tasks, which will be elaborated subsequently:

5.1 Materials Posting and Logistic Management

We posted lecture notes, assignments, project descriptions online in a very organized form. While web-based course material posting has been frequently done, even though BlackBoard is not specifically used, however, what is actually more useful is not only posting the PDF versions of the materials. We think that the students could learn much better by showing multimedia on specific topics. Given that Youtube consists of a lot of useful content, some of the ideas were delivered through these videos. One of the particularly difficult idea to show is the flexible modes within a mechanical structure. A video that simulates these behaviors made this idea much clearer than just pure schematic drawings on the paper. Besides, many different short videos or documentaries were also posted along with the similar topic as supplementaries so that the students could connect them with the real-life or practical issues. For instance, when talking about failures in engineering design, we showed some short documentaries from Henry Petroski, who is an author of many books about engineering failures and designs [22].

UBLearns also provides a very convenient way to communicate with the students using emails. Whenever there is an update online, the instructor sends out an email to inform them. Some times, when some specific students needed attention, specific email could be sent through the interface without having the other students to realize. This also reduced the need to keeping a contact list of the class.

5.2 Forum

The email-based communication approach described previously is rather "static", and there is always a need of more "dynamic" communication outside the classroom. This is because meeting 3 days weekly at an hour each could be very limited in addressing a lot of the class issues. Forum is an attractive and interaction solution to establish such effective communication medium. Such approach is rarely used in a lot of the engineering courses even though some effort has been reported [23]. Forum not only can be used to have the students to interact with the instructor and the TA, more attractively it could also encourage the students to interact with each other. Specifically, the forum-based "Discussion Board" available on UBLearns has been found very useful in providing the software "technical support" through user's experience, i.e. the students posted the questions and the questions are answered by the students. Traditionally, the students expect that the instructor or the TA should know every single aspect of how a software work. However, given the time and the capability limit, most of the time this approach is infeasible. However, creating such real-life forum or technical support environment could encourage the students in the following:

1. They learn to formulate the problems so that the technical support would understand.

2. Given that they need to think when asking the questions, they might find the solution while formulating the problems.
3. This provides opportunity to the other students to provide responses through this medium. The students will learn how to respond to a question.
4. This significantly relieved the huge burden from the instructor and the TA that was needed to handle.

The examples of the postings are illustrated in Fig. 9. However, the issue remained how to encourage the students to participate in these forums. In this course, we implemented bonus points to award students who actively and constructively participate in the "Questions and Answers". In one of the instances, where a student was asking for help in using ANSYS function for the comparison with Pro/MECHANICA solution. Since the authors were not explored to ANSYS, a lot of the questions were actually answered by the other students who were experienced in using ANSYS. In one of the entries, one of the students, who had some industrial experience, actually suggested the ANSYS has more control over the shape functions of the mesh. This valuable information has been successfully conveyed to not only the students, but also the instructor and the TA. Hence, this platform successfully "opened" the questions to anyone in the class, who might able to answer the question.

6 CONCLUSION

In the course evaluation, there were many students who find that the interactive and collaborative approaches have been very helpful in learning the course. Of course, the hands-on CAD and CAE experiences that they gained through extensive exercises and projects were also valuable. Some of them even commented that the interactive nature of the course allowed them to know more new friends within the large lecture hall settings. Some also found out that using UBLearns in logistic planning and email responding were also useful throughout the course. The course also successfully inspired many students to choose design engineer as their career as evident by the recommendation letters wrote by the instructor over the years for the students in the class. Future work includes the use of online blogs and journals to access the students daily or weekly performance. However, the major issue with current blog interface is that it is hard to input mathematical equations.

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MAE477:CAD APPLICATIONS:200801267943 (200801_267943_COMB) > DISCUSSION BOARD > COURSE DISCUSSIONS: PROJECT 2

Course Discussions: Project 2

Tree View | List View

Thread | Remove | Collect | Mark Read | Mark Unread | Change Status to: Published | Go | Search

Date	Thread	Author	Status	Unread Posts	Total Posts
4/7/08 12:10 PM	CONSTRAINTS task 1 -full model	* Nijo Alexander Abraham	Published	0	1
4/6/08 9:53 PM	Parameters	Eric Stein	Published	0	2
4/4/08 7:25 PM	Question 2, Part G	Geoffrey Leach	Published	0	2
4/4/08 9:50 AM	Electronic Submission	Michael Rausch	Published	0	2
4/3/08 5:05 PM	distributed loads in 3-d model	Kurt Bessel	Published	0	6
4/3/08 4:40 PM	verification on beam size	Kurt Bessel	Published	0	2
4/3/08 3:04 PM	evidence of convergence	Amy Schroeder	Published	0	7
4/3/08 1:18 PM	Symmetry for Beam element	Elizabeth Paoletti	Published	0	3
4/2/08 8:01 PM	Project2_Task2_Part-f	Zhen Tang	Published	0	1
4/2/08 6:21 PM	Initialization	Chin Pei Tang	Published	0	1

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OK

(a) Project 2 Discussions

MAE477:CAD APPLICATIONS:200801267943 (200801_267943_COMB) > DISCUSSION BOARD > COURSE DISCUSSIONS: FINAL PROJECT

Course Discussions: Final Project

Tree View | List View

Thread | Remove | Collect | Mark Read | Mark Unread | Change Status to: Published | Go | Search

Date	Thread	Author	Status	Unread Posts	Total Posts
5/4/08 7:54 PM	Optimization	Sasitharan Sithambaram	Published	0	4
5/4/08 4:52 PM	BOM or engineering drawing	Elizabeth Paoletti	Published	0	6
5/4/08 4:41 PM	E-drawings in the powerpoint presentation	Vincent Kostovich	Published	0	2
4/27/08 10:07 AM	Exporting from ProE/ProMechanica	Charles Nasca	Published	0	2
4/22/08 10:15 PM	Conversion from Pro/ENGINEER to Solid Edge	Chin Pei Tang	Published	0	4
4/22/08 9:35 PM	Final Presentation Suggestion	Steven Battaglia	Published	0	5
4/17/08 2:00 PM	ANSYS help	Scott Hall	Published	0	10
4/14/08 7:34 PM	Phase 2	Elizabeth Paoletti	Published	0	2

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OK

(b) Final Project Discussions

FIGURE 9. Discussion Boards

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