# Enhanced Teaching Techniques Applied to an Upper Division Composite Materials Engineering Course with an Emphasis on Aerospace Applications

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BIOGRAPHICAL SKETCH

Professor Joe Stuart

PROFESSIONAL PREPARATION

B.Sc., Metallurgical/Mechanical Engineering, University of Nevada at Reno (1969) M.Sc., Physical Science, University of Southampton, UK (1972)

APPOINTMENTS

2006 to Present Program Director Manufacturing Engineering Technology, OIT 2011 to Present Associate Professor, MMET Department, Oregon Institute of Technology 2004 to 2011 Assistant Professor, Oregon Institute of Technology, Klamath Falls 2002 to 2004 National Accounts Manager, Wagner Electronics 1998 to 2002 President/Owner, Best Tech USA 1985 to 1998 VP and General Manager, Alumaweld Boats Inc & Rogue Trailers Inc. 1984 to 1985 Manufacturing Rep MDA Associates 1981 to 1984 Quality Engineer, International Memories Inc. 1980 to 1981 Design Engineer Balteau Standard 1977 to 1980 Field Engineer, Wisar Construction 1975 to 1977 General Manager Milthorn Toleman Ltd., UK 1974 to 1975 Chief Scientist, Puerto Rico Nuclear Center 1972 to 1974 Engineering Consultant, EPA 1969 to 1970 Metallurgical Engineer, Republic Steel Inc.

Professional Societies:

American Society of Engineering Education, Life time member Society of Manufacturing Engineering, American Society of Mechanical Engineers

PUBLICATIONS

(i)Most Closely Related [1] W.J. Stuart 'Problem Based Case Learning - Composite Materials Course Development – Examples and classroom reflections' NEW Conference, Oct 2011 [2] W.J. Stuart and Bedard R. (EPRI) 'Ocean Renewable Energy Course Evolution and Status' presented at Energy Ocean Pacific & Oregon Wave Energy Trust Conference, Sept. 2010. [3] W.J. Stuart, Wave energy 101, presented at Oregon Wave Energy Symposium, Newport, OR, Sept. 2009. [4] W.J. Stuart, Corrosion considerations when designing with exotic metals and advanced composites, presented at Corrosion Conference of Exotic Metals, Park City, UT, 2009. [5] W.J. Stuart, Ruth Loring, Ed Webster, Frank Cox, Composite materials course development using problem based case learning techniques, National Educators Workshop, Greensboro, NC, 2009. [6] W.J. Stuart, Three pronged approach to sustainability at OIT, presented to faculty and staff at OIT 2008 Fall Convocation, 2008. [7] W.J. Stuart, Sustainability workshop, presented to faculty and staff at OIT 2006 Fall Convocation, 2006. (ii) Other [1] W.J. Stuart, Successful programs that have been enriched by industry and engineering education connections, Proceedings of ASEE Conference, Chicago, IL, 2006.

SYNERGISTIC ACTIVITIES

• Course development for Ocean Renewable Energy for Manufacturing Engineering Technology and Renewable Energy Engineering students: developed and taught a new undergraduate dual listed course, Ocean Renewable Energy, in spring 2010. This course has now also been developed and is offered (and has been taught) as a 'Distance Education' course. • Course and lab development for Advanced Composites for Manufacturing Engineering Technology and Mechanical Engineering Technology students: developed and taught a new undergraduate dual listed course, Advanced Composites, in spring 2009 and winter 2010. • Student advising and course integration in sustainable concepts and life cycle analysis and material selection considerations. • Innovations in teaching: used innovative teaching methods to enhance the learning experience through introducing problem based case learning techniques in classes and course structure; presentation of paper in National Educators Workshop.

COLLABORATORS AND OTHER AFFILIATIONS

(i) Collaborators and Co-Editors Frank Cox, Edmonds Community College; Ruth M. Loring, Nashville State Community College; Wangping Sun, Oregon Institute of Technology; Ed Webster, Institute for Professional Training and Education; John Anderson, Oregon Institute of Technology

(ii) Special Material Expert Curriculum development for National Resource Center-CAM composite materials course for National Resource Center at Edmonds Community College.

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## Abstract:

While developing content for an Advanced Composite materials course for Mechanical Engineers it was decided to incorporate several enhanced teaching techniques that an NSF team had fine-tuned over several years. The 3 credit course in Advanced Composite materials consists of two lectures and a lab where hands on selection and application of composite materials focuses on students designing and building projects in a composite materials lab environment. 'Just in time feedback' mechanisms are used that provide rapid formative feedback and reinforcement of a positive learning experience to enhance the learning process such as: 1) 'muddiest points' and 'most interesting points' identification and next lecture clarification, 2) three to five minute PPT and video segments used in class to fortify concepts that have proved to be confusing or complex in the past or in current lectures, 3) online postings of short segment 'Camtasia' modified PPT explanations for students to refer to as rapid reference sources on particular subjects and 4) 'Youtube' video clips to provide alternative descriptions of lecture items covered. This work looks at examples of these techniques and their effectiveness in a course that is geared toward training engineers quickly to become familiar with extensive advanced composite material nomenclature, concepts, processes and applications. Assessments are illustrated with student work on projects, exams and peer reviewed presentations and student surveys.


## Filling a need:

There is a strong need in the Mechanical engineering program for an elective in Advanced Composite materials as defined by industry, material trends and by requests by students. At the Oregon Institute of Technology this is filled by offering a 3 credit course consisting of two hour long lectures and a three hour lab each week for a ten week term. Today there are over one hundred and sixty thousand materials for engineers to choose from when designing a component and to meet the ever increasing demand for higher strength and

lower weight or possibly higher elastic modulus and lower weight materials, the increase in composite materials has been very significant. No industry has emphasized this need more than aerospace as exemplified by the integration of more than 50% of some of the more modern aircraft being manufactured today. The Lexus is now 65% composite materials and a new hybrid BMW is building solar panels into the carbon fiber body to increase charging to the battery bank by 15%. The attributes of these modern advanced composite materials brings further range, longer fatigue life, more comfortable and safer aircraft and automobiles that use less fuel and are more reliable. We are seeing the use of aramid fiber in more applications like the insulating layer in a lithium ion battery to prevent electrical shorts and in body armor and vehicle armor. Today's engineers need to understand how to select, design, test, and repair these materials in both experimental and commercial applications. Learning about materials in general, let alone composite materials certainly requires learning many new concepts and a new vocabulary of terms. In order to facilitate this process some enhanced learning techniques have been incorporated into this course.

**Enhanced teaching Methods:**

Various methods used at the Oregon Institute of Technology and other collaborating Universities have evolved over several years while working on an National Science Foundation (NSF) grant incorporating 'Just In Time Fast Formative Feedback'. These methods were initially applied in 100 and 300 level 'Materials Science' courses for engineers and engineering technology undergraduate students. It was soon realized that these methods could easily be effective in other engineering courses and this is when it was decided to integrate these ideas into an upper division composite materials course for mechanical engineers. The methods used are the following:

- One of the most effective techniques has been what is referred to as the 'Muddiest Points', the collecting of them, and then clarifying these unclear parts of a class lecture (or 'Muddy Points') using several supportive methods as quickly as possible. The first term of implementing the collecting of the Muddiest Points from a lecture; surveys were collected during class from a hard copy questionnaire. The first term, since the questionnaire was handed out during lecture, there was a 100% response rate from students in the lecture that day (which for class attendance meant an overall response rate of 94.
  When a class begins, a short questionnaire is distributed to the students and they are asked to fill it out during the last 5 minutes of class after the lecture has been presented and discussions have finished. What was found to be most effective was

to have the students each describe in one sentence for each point, what was not clear or the 'Muddiest Point' (or 'Muddiest Points') in the lecture.

- This evolved to additionally asking what was the 'most interesting point' so that the teacher could get an understanding of what was not well understood along with what was enjoyable (and probably most clearly understood). These questionnaire surveys were then collected at the close of class and reviewed to get an understanding of what items most needed to be clarified before moving on to new topics. There are then several ways to address these 'Muddiest Points' in a timely manner:

  1) PowerPoint slides at the start of the next lecture: One of the easiest ways to address these 'Muddiest Points' is to create one or two PowerPoint slides that explain the topic in question. It seems to be better to explain the Muddy Point in a somewhat different manner than was done in the initial lecture. It also seems to have more impact if a student, a teaching assistant or someone other than the original lecturer delivers this clarification. There are several ways to accomplish this. A student who has correctly answered or described the topic in previous classes as a homework item can perform the review. A teaching assistant can also perform the review and it has been found to be beneficial to record these or at least have the teaching assistant provide a set of 'narrated PowerPoint Slides' so that the slides can be collected in a data bank and used for future classes. Students engage and are very responsive to hearing these reviews from other students.

  2) Videos: At first, a couple of videos were used from 'Muddiest Points' collection on 'YouTube5' but it was found that if the explanations are too long then they lose impact. For best results, it is important that if videos are used to help clarify a topic, they should be limited to two to five minutes in length. If there is something that is very complex then this can be stretched another minute or two, but generally no longer than five minutes total. Our team is now working on expanding a database of brief videos that we can all pull from to clarify the 'Muddiest Points'. These can be made right in the classroom with a student or teachers assistant as the lecturing person reviewing a PowerPoint explanation. If the video is focused and on point then this method is very effective. Our experience has shown that videos need to be no longer than 5 minutes to maintain the full attention of the student and also the students are more willing to review them several times (if they are made available on either YouTube[1] or on Blackboard[2]) if they are fairly concise.

3) Pencast: Another tool that the team is planning on incorporating into their JTF project is a Pencast[3]. A Pencast is a 'smart pen' that connects with a computer so that live explanations can be recorded as hand written and orally explained. These recordings can be used repeatedly for efficient use of explanation time, and can be converted to video format and posted on YouTube5 and Blackboard[1]. The cost to purchase a Pencast[3] tool is less than $200.

4) Quizlet is designed to aid students in their studying. It's set up for explanations and pictures to be linked to topics of importance. A professor or teacher's assistant can create a database of terms, topics that correlate to each chapter. One tool built in Quizlet, is the ability for it to generate tests. When generating the test, there are choices between written, matching, multiple choice, true/false, or any variation of them, and then the ability choose the number of questions which are to be incorporated into the test.

**Benefits**:

**Student engagement:** One of the fastest and most rewarding benefits of using these learning tools in the classroom is the significant increase in student involvement in discussions and having many more students answer reflective questions and make solid attempts at solving problems. These tools give the students an increased understanding of the core concepts which increases their confidence and gets them involved in discussions. This process needs to be carefully coached with encouragement and acknowledging success in student attempts to answer questions posed by the instructor. At the end of a term of implementing the JTF teaching methods, the students were given a survey on 'Muddiest Points' and asked if they felt 'Muddiest Points' was beneficial to their learning. The student's responses are displayed in Table 1.

| *Table 1: Survey of Students Collected at End of Each Term* Students Opinion: | **WinterTerm 2014** | | **Fall Term 2014** | |
|---|---|---|---|---|
| **The "Muddiest Points" Daily Reflection Used in this Course…** | **Agree:** | **Disagree:** | **Agree:** | **Disagree:** |
| **Was an effective way to increase my engagement in the course.** | 75.5% | 24.5% | 77.8% | 22.2% |
| **Helped me better understand my own learning.** | 70.2% | 29.8% | 78% | 23.5% |

**Student Retention:** A 'Muddiest Points' questionnaire was used to find how many students have been retained in the class from the second week of term to the final week of term and there seems to be consistency with a retention rate of over 90%. This is compared to data from earlier classes before JTF was implemented, that illustrated a retention rate of 75 to 85%. See Table 2. During Fall 2014 there was a weekly attendance collected and the overall daily attendance was never below 90%.

| *Table 2: Retention Rate of Students* | Winter 2014: | Fall 2014: | |
|---|---|---|---|
| Percent of Students To Complete Course: | 82% | 92% | |

**Subject Knowledge**: The tools used for JTF teaching allow the material and particularly the difficult concepts to be easily reviewed several times over very easily and in different presentations so the student can grasp these concepts through repetition that is engaging and not boring. The very nature of the JTF methods gives the teacher fast feedback on how the class is doing and provides solid information so that a pace can be established that is in step with the learning capabilities of the class. Much of the time spent in carefully representing a response to the 'Muddiest Points' can be amortized over many terms of presenting the material as it is fairly common for the unclear points to be repeated again in future courses so any videos or PowerPoints can be used over again. The more complex concepts are reviewed quickly in a short time and then reinforced in discussions and finally assessed in homework and exam questions. Students who were asked if the 'Muddiest Points' helped them in succeeding in this course, showed a very positive response as shown in Table 3.

| *Table 3: Survey of Students at the End of Each Term* Students Opinion: | **Winter Term 2014** | | **Fall Term 2014** | |
|---|---|---|---|---|
| **The "Muddiest Points" Daily Reflection Used in this Course…** | **Agree:** | **Disagree:** | **Agree:** | **Disagree:** |
| **Helped me to be successful in this course.** | 74.5% | 25.5% | 70.7% | 29.3% |
| **Decreased my interest in the Content of this Course.** | 8.8% | 91.2% | 0% | 99% |

**Student Scores:** The students scored higher in exams when these methods were used and students became more comfortable in discussing the more difficult concepts in their team presentations. The final grades have been increasingly improving also as shown in Table 4.

| *Table 4: Final Grades by Term* | A | B | C |
|---|---|---|---|
| (Before JTF Implementation) | 42% | 38% | 20% |
| Winter 2014 | 51% | 45% | 4% |
| Fall 2014 | 50% | 47% | 3% |

**Learning becomes easier and more accurate:**

Students have been very positive about using the enhanced learning methods in the classroom and like hearing from other students explaining some of the more difficult concepts. They like the short videos and short powerpoints explaining any 'Muddy Points' and then like the instructor feedback that indicates that the instructor is listening to them and connecting with them.

**Difficulties of implementation**:

Learning new software is always time consuming, however if the instructor takes the time to do this then making interactive videos with software like 'Camtasia' can be very friendly to the student learner. This as mentioned before can also lead to a bank of learning videos that can be used by other instructors, students and in the future. The expense of the new technology can also be a deterrent however many mini grants are available for developing coursework.

Just as learning PowerPoint was a challenge, so now is learning how to video a concept response. The tools once learned and developed can be a very powerful and time saving tool that will help many students learn new material quickly and more effectively and they can view it over and over again on their own schedule.

**Examples of work**:

The thermoset vs thermoplastic video's link is: https://www.youtube.com/watch?v=4Is5SOL8-9A&feature=youtu.be

Precipitation Hardening video: http://youtu.be/fsTUDSrXt84

Heat treatment of ferrous materials: https://www.youtube.com/watch?v=zIiMih9kfhs

Stress Strain Diagram: https://www.youtube.com/watch?v=_Oo8rn1eeV0

## CONCLUSION:

'Just In Time Fast Formative Feedback' (JTF) teaching techniques are a fast and efficient way to explain topics which are a challenge for students to understand. The methods build on finding out what is not clear and then progressively reinforcing solutions as quickly as possible in a prioritized fashion so that an understanding becomes clear. JTF has been used in freshman and junior level engineering materials science courses at Oregon Institute of Technology and it has improved the knowledge gained by the students, student retention, student engagement as well as exam scores and final grades in these classes. It has become very apparent that this collection of JTF teaching tools and techniques can be used in many courses to better prepare our students and enhance their learning experience. With many available resources; expanding the material available to students is very important. With more research and time, the foundation of material that will be available to the students will ensure their success.

## References:

**1) YouTube.com**

2) Pencast. LiveScribe Inc., 2013, Web. 5 Jan 2014

3) Quizlet. Quizlet. 2014. Web 6 Jan 2014