

## **AC 2009-1118: IMPROVING A MANUFACTURING CLASS BY ADDING AN EXPERIMENTAL SESSION**

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# **The Improvement of a Manufacturing Class by Adding an Experimental Session**

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## Abstract

The author of this paper has been teaching a graduate-level manufacturing class: MMAE 546 Advanced Manufacturing Engineering. The author has made an effort to improve the class by adding an experimental session to this previously lecture-only class, and this effort will be presented in this paper. The effect of the experimental session on the students' learning quality improvement and study interest stimulation will be discussed. Students' comments and feedback are also provided.

## Introduction

Since the author joined the Department of Mechanical, Materials and Aerospace Engineering (MMAE) of University A in 2007, he has been teaching the graduate-level class MMAE 546 Advanced Manufacturing, which is offered once a year. The objective of the class is to make the students understand some traditional and non-traditional manufacturing processes, be familiar with the relevant equipments and capabilities of each process, and know some of the important underlying engineering and physical theories for each process. The topics covered include computer numerical control, powder metallurgy, abrasive machining (grinding, etc.), welding, micro/nanomanufacturing, and laser-based manufacturing, etc. The class had been offered for around 10 years before the author joined the department, and had always been a lecture-only class without any experiment.

The fall semester of 2007 is the first semester when the author taught this class, and it has been found that many students feel that the class is a little bit boring, and one of the reasons is that the class does not have an experimental section, and the students do not have the opportunities to see and/or practice what they have seen in the lecture notes or textbooks. For example, during the final official evaluation of the class organized by the university, some students commented:

- *“This course is only theory based. Student can not have any practical knowledge about the different machining process.*
- *“Student should have the opportunity to do practical manufacturing project.”*

It has also been found that the attendance rate became lower as the class went on, and in some cases it even dropped to below 30%, implying the lack of the interest in the class from the students.

Different instructional methods generate different retention rates in brains<sup>1</sup>. Compared with lecture generating 5%, teaching others/immediate use of learning generates 90%, which can be achieved through an experimental section effectively. It is also suggested that teachers should “provide opportunities for students to do something active” for a better teaching quality<sup>2</sup>.

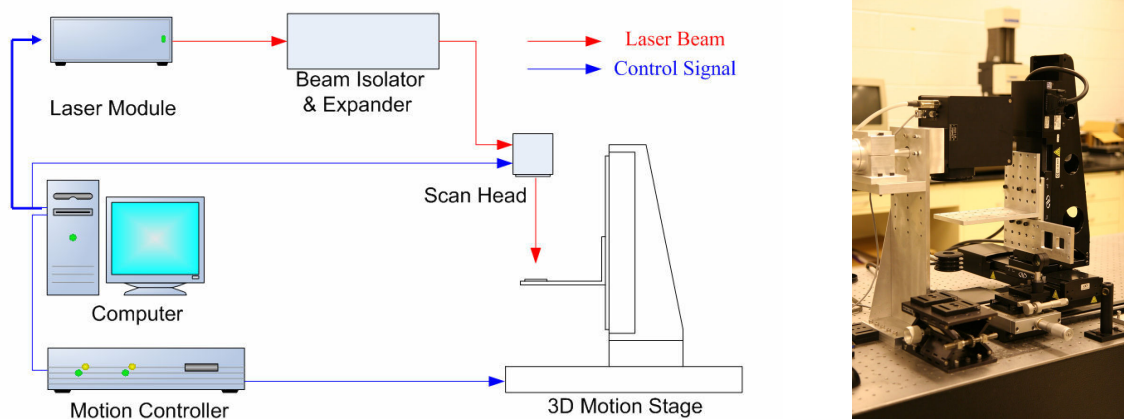
Motivated by the above fact, the author decided to add an experimental section to the class when he taught the class for the second time in Fall 2008. It is expected that this will improve the author's teaching quality in this class.

## Design and Organization of the Experimental Section

Because the class has been offered by the department for many years without an experimental section, it is still not clear if or not adding one will really improve the teaching and learning quality of the class. Therefore, the Fall 2008 semester is more like a “testing semester” for this, and only the resources in the laser-based manufacturing lab under the direction of the author were used for the experimental section of the class. Initially, three to four sections were planned. However, due to the facility and time restriction, it turned out that eventually only two experiments were carried out.

The class had a size of around 20 students, which was divided into 4 groups with each group having around 5 students. The students within each group did the experiments and data collection together. However, each group member was required to submit a separate lab report individually. The lab report was graded based on its content, format, and language. Because lasers were involved in the experiments, the students were given laser safety training before the experiments. Also, during the experiments, the operation of the laser itself was mostly carried out by the teaching assistant, who is also a graduate student of the author.

The schematic of the system used in two experiments is shown in Fig.1 (a) and a real photo of the system is given in Fig. 1 (b). The laser module can be operated either in continuous mode or pulsed mode, and the laser beam is expanded by the beam expander, and delivered and focused by the scan head onto the surface of the workpiece sitting on a three dimensional (3D) computer numerical controlled (CNC) linear motion stage with submicron accuracy. The laser, scan head, and motion stage are controlled and synchronized by the computer.



**Figure 1.** The system used for the experiment (a) the schematic; (b) the real photo.

Lab 1 gives the students an opportunity to practice the CNC programming they have learned in the lecture part of the class. The students need to write a CNC program to control the motion of

the 3D motion stage, so that laser beam can leave a pre-defined pattern on an optical sensitive paper sitting on the stage.

Lab 2 gives the students an opportunity to apply the heat transfer theory to analyze the thermal transport process in laser-based manufacturing, and compare what they have calculated with what they have observed in the experiment. The students need to apply an analytical solution of heat conduction equation to calculate the required minimum laser power to melt the surface of an aluminum sample and compare model predictions with experiments.

Because the class had an Internet section and the internet students can not do the experiments. Hence, the experimental process was captured by video and posted on the class website as a demonstration to the Internet students. Also, the students in the classroom were also given the opportunity for not participating in the experimental section (the corresponding grading weight will be transferred to their homework). However, it turned out that all the students in the classroom (the non-internet students) had participated in the experimental section, implying their strong interest in this.

## **Results and Analysis**

Despite the fact that only two experiments were organized, the response from the students was surprisingly good. It has been observed that most students had shown a much stronger interest in the class (both the lecture part and the lab section) in Fall 2008 than Fall 2007. The attendance rate maintained at around 90% or higher most of the time through the whole semester. Figures 2 and 3 show the response of the students in the final anonymous class evaluation of MMAE 546 in Fall 2008 to some survey questions on the lab session of the class.

The following are some comments from the students on the experimental section:

- *“Laboratory experiments were very helpful in understanding course material “*
- *“The labs are extremely helpful”*

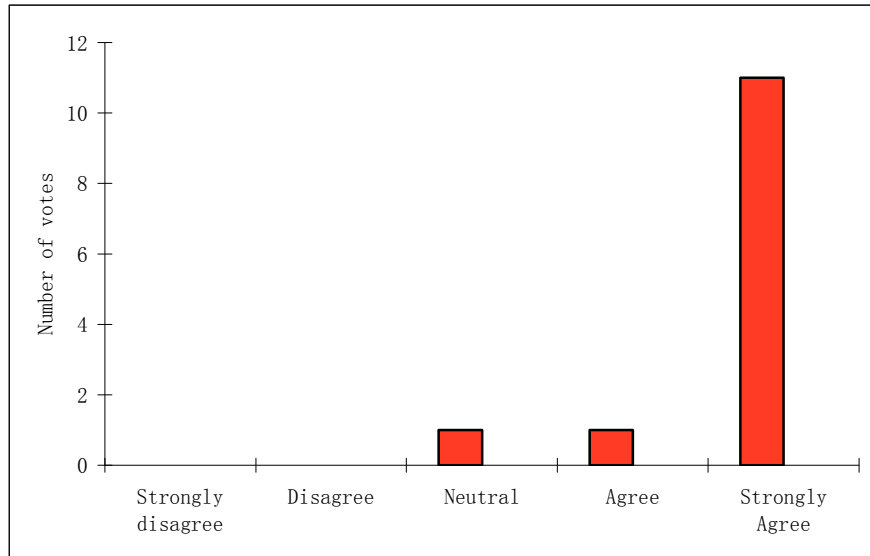
The comments above and Figures 2 and 3 have shown that most of the students strongly agree that adding an experimental section has improved the class quality, and also the lab session has been well organized.

Figure 4 and Figure 5 show the students' evaluations on the author's teaching quality (in the official class survey organized by the university at the end of the semester) for MMAE 546 in Fall 2007 and Fall 2008, respectively. It can be seen that the teaching quality has had a significant jump. In Fall 2007, no students feel the author's teaching is "Excellent". However, in Fall 2008, 77% students give an "Excellent" rating.

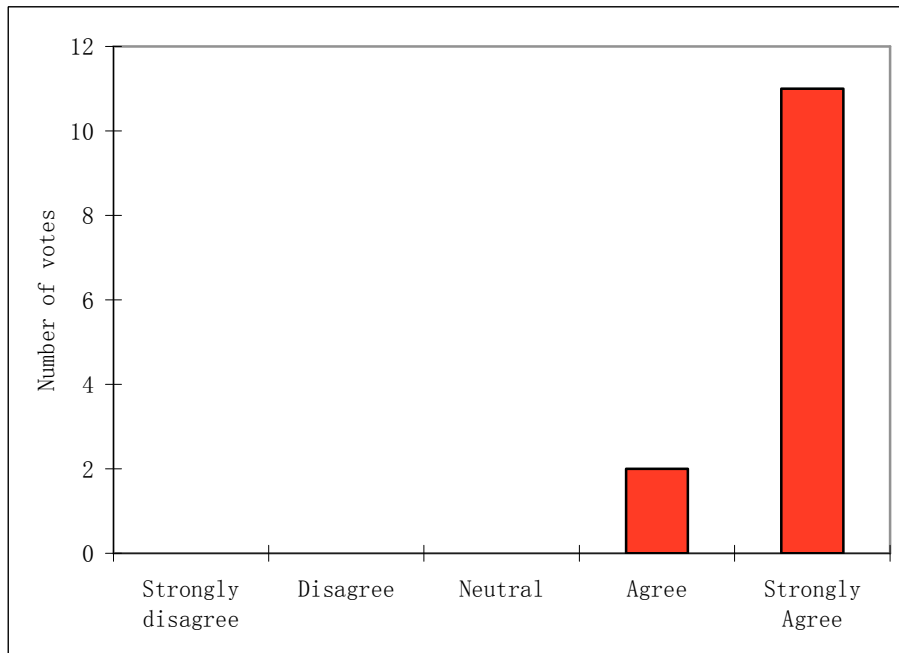
It is believed that as a junior faculty, the author's teaching quality should increase as he gains more teaching experience. However, the increase of the teaching experience alone is difficult to completely explain the jump of the teaching performance. It can be seen from Fig. 6 that the students' evaluation on the author's teaching performance increases from 3.54 to 3.76 from Fall 2007 to Spring 2008 (the full grade is 5). However, the evaluation jumps to 4.77 in Fall 2008 with a much higher increasing rate. This is difficult to be explained by the teaching experience

increase alone, and it is believed that the adding of the experimental section in Fall 2008 should have played an important role here, particularly considering the students' response in Fig. 2.

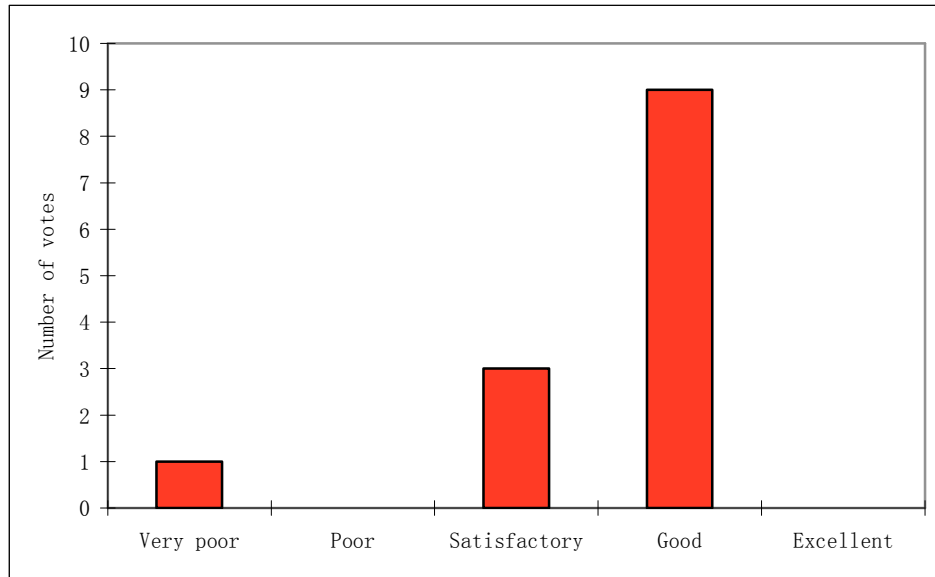
The positive response from the students suggests that the experimental session should still be incorporated when the class is offered again in the future. The students' response in Fig. 7 suggests that more experiments should be organized in the experimental session of the class.



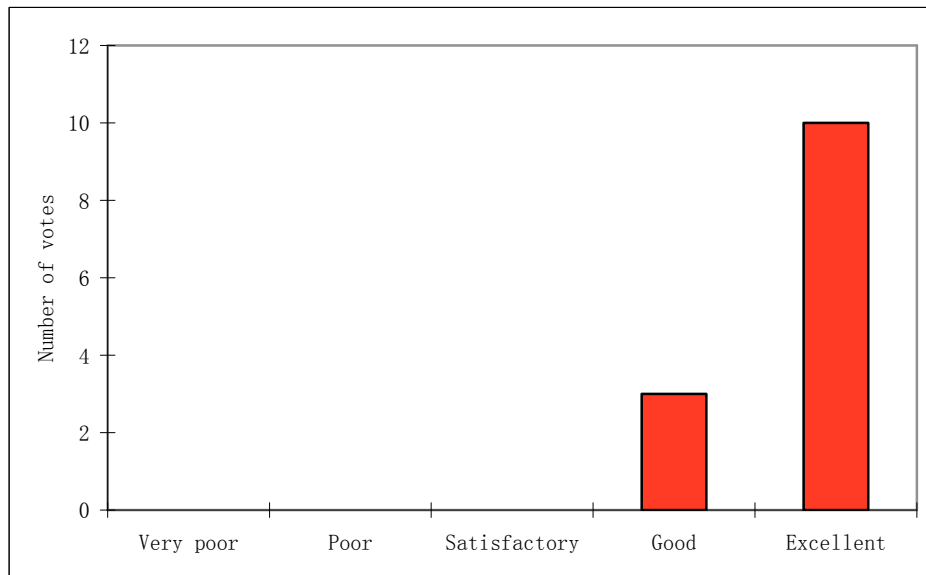
**Figure 2.** Students' response to the question “*The adding of lab session has improved the class teaching quality*” in the final class evaluation of MMAE 546 offered in Fall 2008.



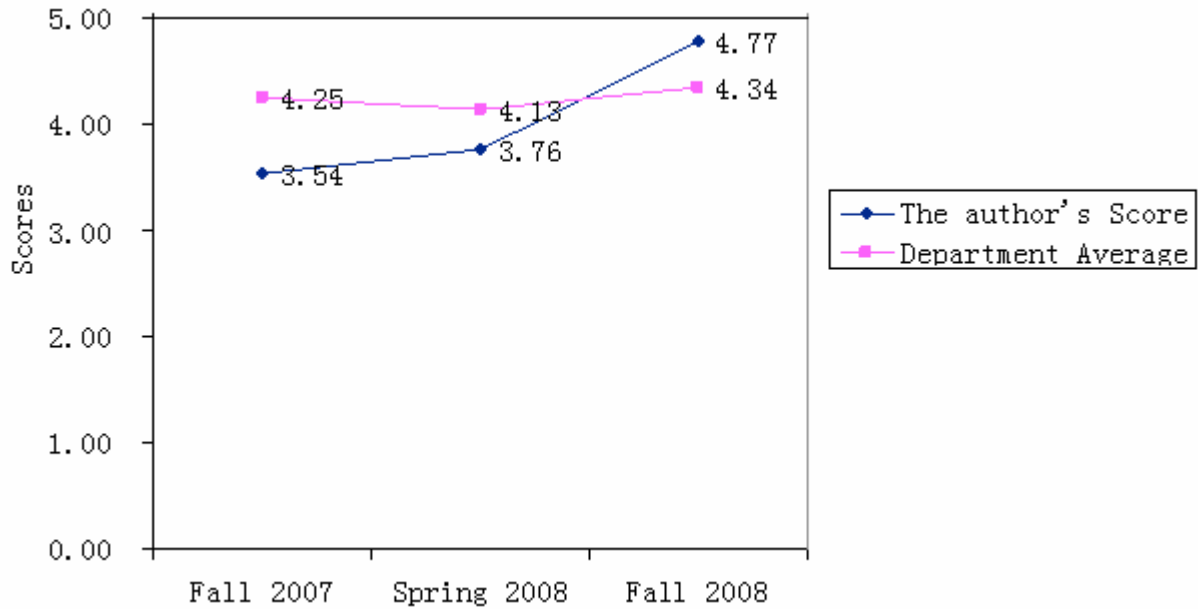
**Figure 3.** Students' response to the question “*The lab session is well organized*” in the final class evaluation of MMAE 546 offered in Fall 2008.



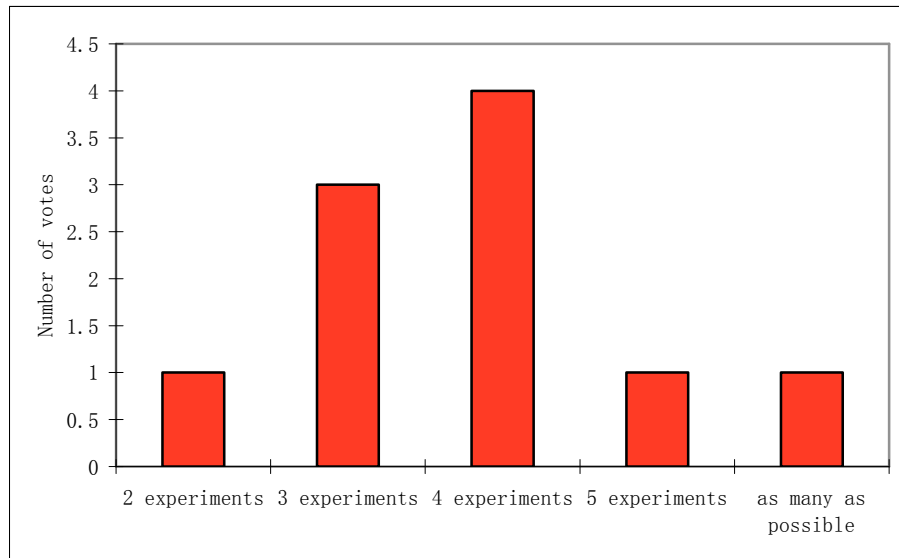
**Figure 4.** The students' evaluation on the author's overall teaching quality for MMAE 546 in Fall 2007.



**Figure 5.** The students' evaluation on the author's overall teaching quality for MMAE 546 in Fall 2008



**Figure 6.** The students' evaluation on the author's overall teaching quality in Fall 2007, Spring and Fall 2008; full grade is 5.0 (Fall 2008 is the first semester when a lab session was added to MMAE 546).



**Figure 7.** The students' response to the question “if the lab session is organized again in the future, what is the number of organized experiments you think most suitable”

## Conclusions

The author is a junior tenure-track faculty who has just joined University A in Fall 2007, and hence only has the opportunity to teach the class of Advanced Manufacturing Engineering (MMAE 546) twice since Fall 2007. Also the number of students in the class is only around 20 to 25. Therefore, the number of responses from the students in the class survey can not be very high. Despite of that, the students' response is so positive that it is safe to believe that adding of



the experimental session in the manufacturing class can improve the teaching and learning quality. It will increase the students' interest in the class and improve the students' attendance rate in the classroom. The students' response also shows that more experiments should be organized in the lab session in the future.

## References

- [1] Sousa, D.A., (2001), *How the brain learns: a classroom teacher's guide*, Corwin Press, CA.
- [2] Felder, R.M., and Silverman, L.K., (1988), "Learning and teaching styles in engineering education", *Engineering Education*, 78(7), 674-681.