AC 2012-3166: INNOVATIVE APPLICATIONS OF CLASSROOM RESPONSE DEVICES IN MANUFACTURING EDUCATION

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Innovative Applications of Classroom Response Devices in Manufacturing Education

Abstract

Classroom response devices (clickers) are now extensively used in all types of courses. The authors have introduced clickers into undergraduate manufacturing courses. Due to the fast-paced nature of manufacturing courses today, content that formerly spanned up to four courses is combined into a single course. This consolidation made student involvement more difficult as the amount of information covered in the course has greatly increased. Course consolidation is also found to encourage traditional lecture-based approaches and rote learning. The use of clickers encourages a more active learning environment where student engagement is increased and where the instructor may immediately evaluate the comprehension of specific concepts in real-time and immediately discuss any misconceptions which are discovered with the class resulting in an ideal formative assessment tool. This technical paper reports the findings collected from various manufacturing technology courses which intensively used clickers as an assessment tool.

Keywords: formative assessment, summative assessment, clickers, classroom response devices, active learning, manufacturing, engineering technology, industrial technology

Introduction

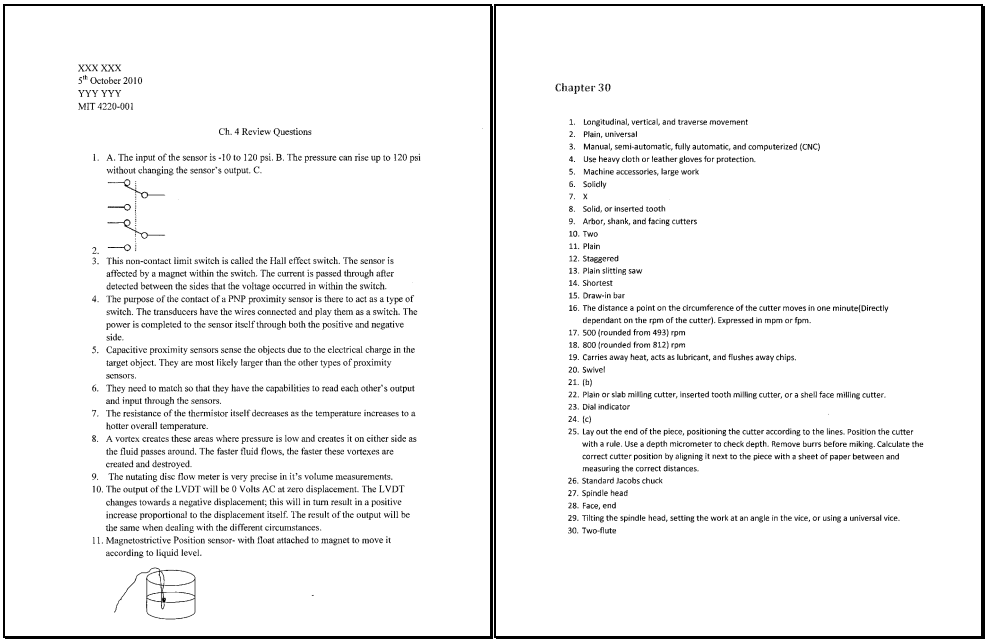
The curriculum in the Manufacturing & Industrial Technology (MIT) program at Tennessee Technological University (TTU) is extremely fast-paced. Traditional manufacturing technologies such as CNC milling, turning, metal casting, and welding used to be the cornerstones of the program. With the rapid advance of technology, a number of new subjects have been added to the program. Electronics and automation, strength of materials, and rapid prototyping are just a few of the courses added to the program in recent years. The addition of these new courses has required consolidation of traditional manufacturing courses. Students now learn the same material in one course that used to be taught previously in two to four courses. Homework assignments, laboratory assignments, mid-term, and final exams are the typical assessment methods instructors would use in these courses. These typical assessment methods used in manufacturing courses have several disadvantages. Students are not as involved in lectures as they could be, and graded homework assignments delay feedback from instructors to students by one or more weeks. Instructors search for alternative mechanisms to get students' attention and keep it.

To address the limitations of traditional course delivery, the authors developed and implemented hybrid course practices initially. There were a number of advantages to using web-based course management systems in the delivery of their courses. Although the satisfaction scores for students' learning outcomes were very high, the issue of providing timely feedback on their assigned homework was a challenge. Responding to positive results experienced by other instructors in manufacturing education[1], the authors of this paper began using Classroom Response Devices (Clickers) as a tool to assess students' learning as an alternative to homework;

therefore the goal of this paper is to report the experiences of implementing Clickers in nine, manufacturing-related course-sections. Four course-sections delivered without the use of Clickers are used as controls for comparison. The authors have evaluated the impact of using Clickers on student-involvement from both the instructor and student perspectives. Student satisfaction using Clickers is measured directly along with overall course satisfaction. The authors discuss the pros and cons of utilizing Clickers, best practices, and novel approaches. The initial results of utilizing Clickers for formative assessment are also discussed.

Comparison of Assessment Methods

Formative assessment has been shown to be one of the most effective methods to support learning by students.[2] Traditional methods of formative assessment in manufacturing courses usually consist of homework and paper-based quizzes in class. The following are two typical examples of homework assignments completed by students:



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Ch. 4 Review Questions

1. A. The input of the sensor is -10 to 120 psi. B. The pressure can rise up to 120 psi without changing the sensor's output. C.
2.
3. This non-contact limit switch is called the Hall effect switch. The sensor is affected by a magnet within the switch. The current is passed through after detected between the sides that the voltage occurred in within the switch.
4. The purpose of the contact of a PNP proximity sensor is there to act as a type of switch. The transducers have the wires connected and play them as a switch. The power is completed to the sensor itself through both the positive and negative side.
5. Capacitive proximity sensors sense the objects due to the electrical charge in the target object. They are most likely larger than the other types of proximity sensors.
6. They need to match so that they have the capabilities to read each other's output and input through the sensors.
7. The resistance of the thermistor itself decreases as the temperature increases to a hotter overall temperature.
8. A vortex creates these areas where pressure is low and creates it on either side as the fluid passes around. The faster fluid flows, the faster these vortexes are created and destroyed.
9. The nutating disc flow meter is very precise in it's volume measurements.
10. The output of the LVDT will be 0 Volts AC at zero displacement. The LVDT changes towards a negative displacement; this will in turn result in a positive increase proportional to the displacement itself. The result of the output will be the same when dealing with the different circumstances.
11. Magnetostrictive Position sensor- with float attached to magnet to move it according to liquid level.

Chapter 30

1. Longitudinal, vertical, and traverse movement
2. Plain, universal
3. Manual, semi-automatic, fully automatic, and computerized (CNC)
4. Use heavy cloth or leather gloves for protection.
5. Machine accessories, large work
6. Solidly
7. X
8. Solid, or inserted tooth
9. Arbor, shank, and facing cutters
10. Two
11. Plain
12. Staggered
13. Plain slitting saw
14. Shortest
15. Draw-in bar
16. The distance a point on the circumference of the cutter moves in one minute(Directly dependant on the rpm of the cutter). Expressed in mpm or fpm.
17. 500 (rounded from 493) rpm
18. 800 (rounded from 812) rpm
19. Carries away heat, acts as lubricant, and flushes away chips.
20. Swivel
21. (b)
22. Plain or slab milling cutter, inserted tooth milling cutter, or a shell face milling cutter.
23. Dial indicator
24. (c)
25. Lay out the end of the piece, positioning the cutter according to the lines. Position the cutter with a rule. Use a depth micrometer to check depth. Remove burrs before miking. Calculate the correct cutter position by aligning it next to the piece with a sheet of paper between and measuring the correct distances.
26. Standard Jacobs chuck
27. Spindle head
28. Face, end
29. Tilting the spindle head, setting the work at an angle in the vice, or using a universal vice.
30. Two-flute

Figure 1: Examples of traditional homework assignments

As a formative assessment tool, however, these instruments have several significant disadvantages: 1) feedback to students is significantly delayed, 2) students are able to maintain misconceptions until corrected by review of homework results or by incorrect answers in summative assessment, and 3) students are often late submitting traditional homework assignments creating a disconnect between the instrument and classroom learning. To address the deficiencies in standard homework for formative assessment, methods such as short quizzes and engaging students with response cards have been tried and found somewhat effective for small class-sizes. The authors of this work were searching for methods that would work for larger class sizes and would provide immediate feedback to students and the instructor. The use of classroom response systems have been shown as an effective method of enhancing learning in larger classroom settings.[3]

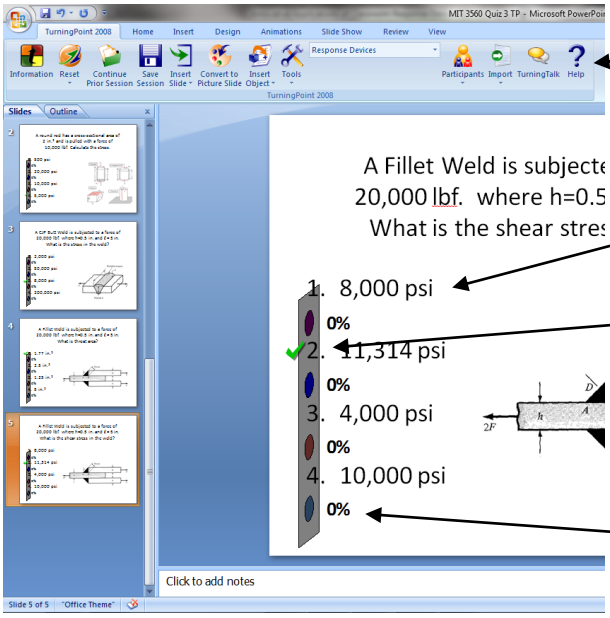
Improvement in formative assessment was measured by Roselli and Brophy in Biomedical Engineering courses through the addition of Clickers.[4] The hypothesis tested in Roselli and Brophy was based on observations by Brosvic where students' retention was significantly improved when rapid-feedback methods of formative assessment were utilized.[5] Significant improvement in overall course performance was also measured versus "clicker performance" in Dawson.[6] Based on the positive results discussed in the literature, the authors of this paper chose to use Clickers as a method to improve traditional manufacturing courses.

"Clicker Quizzes"

The authors generally teach a set of required major courses each semester. Four courses offered by the MIT Department in Fall 2010, prior to beginning administering "Clicker Quizzes," are used as controls. In Spring 2011, the same four courses were delivered with traditional homework until mid-term then with "clicker quizzes" after mid-term. In Fall 2011, the four courses were offered entirely with "clicker quizzes". The following is a list of the courses in this study:

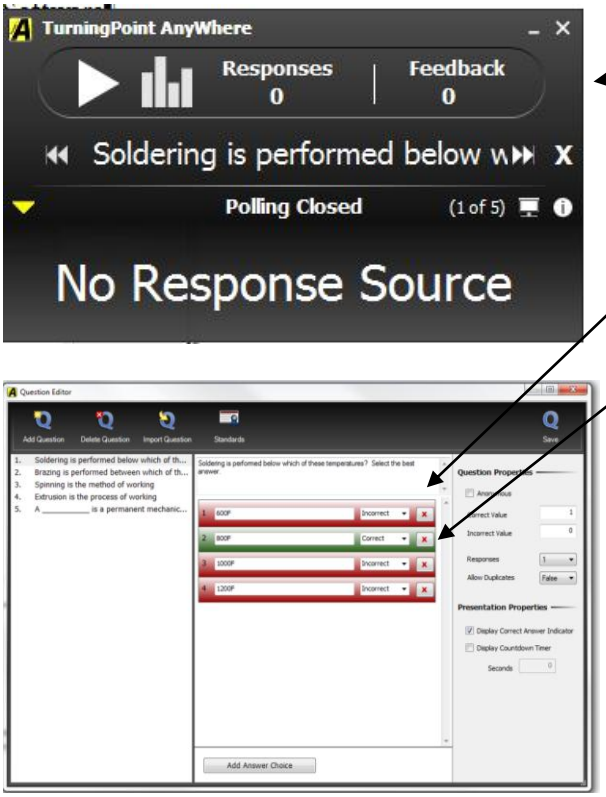
1. MIT-2063 - Metal Manufacturing Technology - Machine tool functions and use of hand tools and machines used to forming metals. Introduction to cutting and welding.
2. MIT-3060 - Computer Numerical Control Machining Practices - Theory of numerical control equipment and programming for machine setup and operation of CNC equipment.
3. MIT-3560 - Advanced Welding - An in-depth experience in welding and inspection procedures. Weld design.
4. MIT-4220 - Industrial Automation and Robotics - Studies in the theory and application of industrial automation and robotics relating to manufacturing.

The technology provider for the hardware and software used in this study was courtesy of Turning Technologies.[7] In the beginning of the study, the authors were faced with their first major decision: to utilize TurningPoint or TurningPointAnywhere software to deliver "clicker-quizzes." Figures 2 and 3 show "screen shots" of these two systems. While the TurningPointAnywhere software is very convenient, may be executed directly from a flash drive, and makes quiz composition very rapid, it had one major disadvantage: the inability to insert graphics alongside the questions. To overcome this limitation, the authors ultimately chose to use TurningPoint software which acts as an add-on to Microsoft PowerPoint. While automating question and answer entry, display of correct answers, and display of answer histograms during polling, by running on top of MS PowerPoint, TurningPoint gave the authors the ability to easily display graphics, videos, or other multimedia content alongside the question being asked.



- TurningPoint software adds a tool bar to Microsoft PowerPoint
- Question/Answer entry is automated.
- Author selects correct answer.
- Author inserts graphics as desired
- Histogram of correct answers is automated during polling.

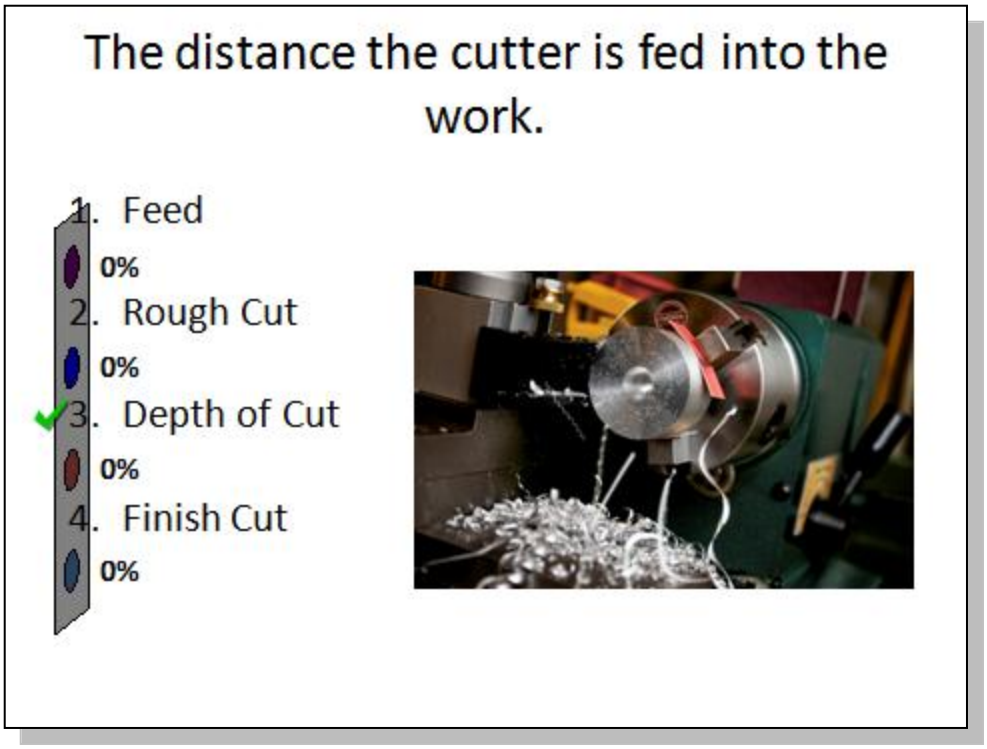
Figure 2: TurningPoint Software

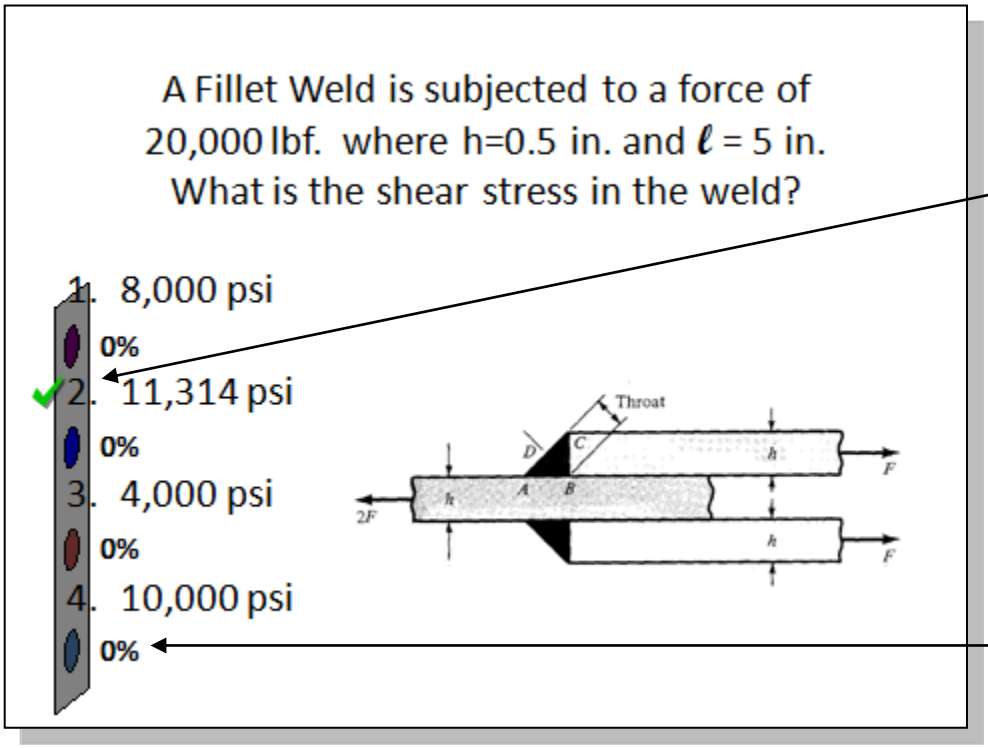


- TurningPointAnywhere software is stand-alone
- Question/Answer entry is automated.
- Author selects correct answer.
- Graphics may not be inserted
- Histogram of correct answers is automated during polling.

Figure 3: TurningPointAnywhere Software

Figure 4 shows an example of "Clicker Quiz" questions from two separate courses.





Correct answer is shown with green checkmark after question is closed

A histogram of answers is shown.

Figure 4: Example "Clicker Quiz" Questions

For some quiz questions, the display of a graphic is integral to the delivery of the question while in others it simply provides students a mnemonic for improved performance. The authors are

only able to compare these two software packages with each other as the technology is new to them, therefore no value judgment of these software packages versus those of other manufacturers is offered. The authors utilized true/false, multiple choice, and numerical response question formats.

Figure 5: ResponseCard NXT

Figure 6: ResponseCard Receiver

The response device provided for this study was the Turning Technologies ResponseCard NXT. The use of clickers was new to the authors, therefore no value judgment of this response device versus other response devices is offered. Observations of the pros and cons of this device is discussed in **Pros and Cons**. Responses from the ResponseCard NXT are received by the ResponseCard Receiver which the authors found best inserted into a USB port on the monitor of an instructor's workstation for best RF reception.

Survey Results

While many of the students in this study had prior experience with the use of clickers in other courses, most of those courses were non-major, general education courses. In major coursework, homework and paper-based quizzes were the norm for most of these students. The authors expected the introduction of clickers in these major courses to be met with resistance. Some students responded that they were using three different clickers in three different freshman/sophomore classes. To eliminate the financial aspect as a negative influence, clickers were loaned to the students in this study and collected at the end of the course.

While initial comments concerning the use of clickers were generally negative, survey results at the end of the courses were surprisingly positive. Figure 7 shows survey results from Fall 2011 courses which were delivered with all clicker-based formative assessment.

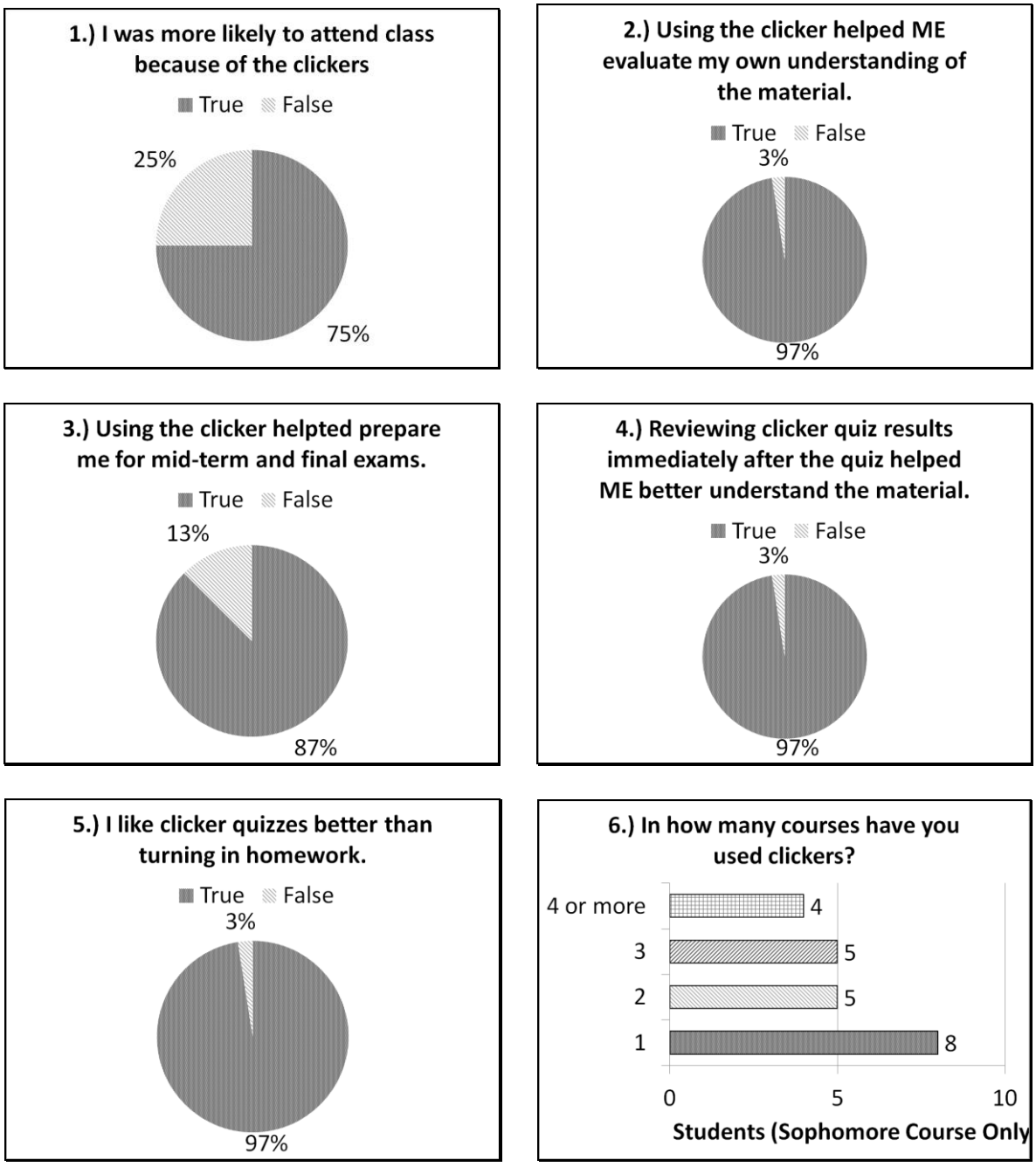


Figure 7: Student Clicker Survey Results

Except for Question 6, the population size for each question was 40 distributed across multiple courses. Results were independent of student class level (freshman, sophomore, etc.) and course level with the exception of Question 1: whether the use of clickers encouraged attendance

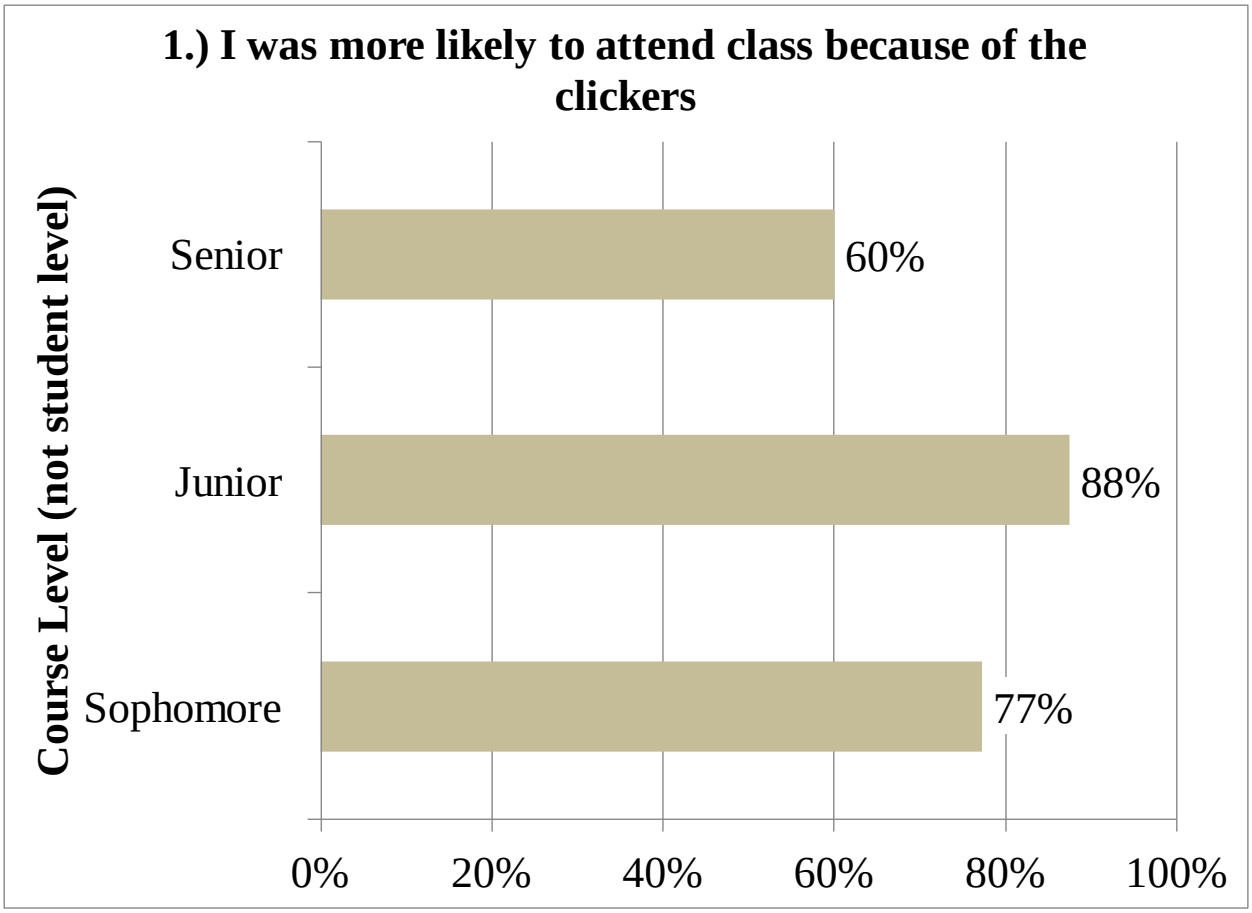


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Figure 8: Attendance Likelihood by Course Level

While statistical significance is not determined, anecdotal evidence supports that the use of clickers in junior-level courses most strongly affects attendance where it is possible that students would have attended senior-level courses whether or not clickers were used. The authors observed in the sophomore-level course that attendance was 94.2% in the traditional course delivery and 94.9% in the clicker-based course delivery. It is important to note that these are lab-based courses and failure to attend has strong negative consequences on students' grades. This may overwhelm the effect of utilizing clickers.

Traditional vs. Clicker-Based Course Satisfaction Results

Students in each of these courses were also given the IDEA Assessment to rate instruction and courses.[8] Student satisfaction with traditional instruction and assessment in Fall 2010 was already very high, with overall ratings at 64.67% versus national averages and 56.33% versus TTU scores. During Spring 2011, when Clickers were introduced at mid-term, scores were similar with the exception of "A. Progress on Objectives." Insufficient data exists to determine if this difference is statistically significant, although it is below the margin of error reported by the results of the IDEA Assessment as a whole. In Fall of 2011, the course was delivered with all clicker-based formative assessment. "A. Progress on Objectives" appears to be consistent

with the "No Clickers" approach. The deviation for the "Half Clickers" approach may be due to the rapid switch from "Homework" to "Clickers" in the middle of the course.

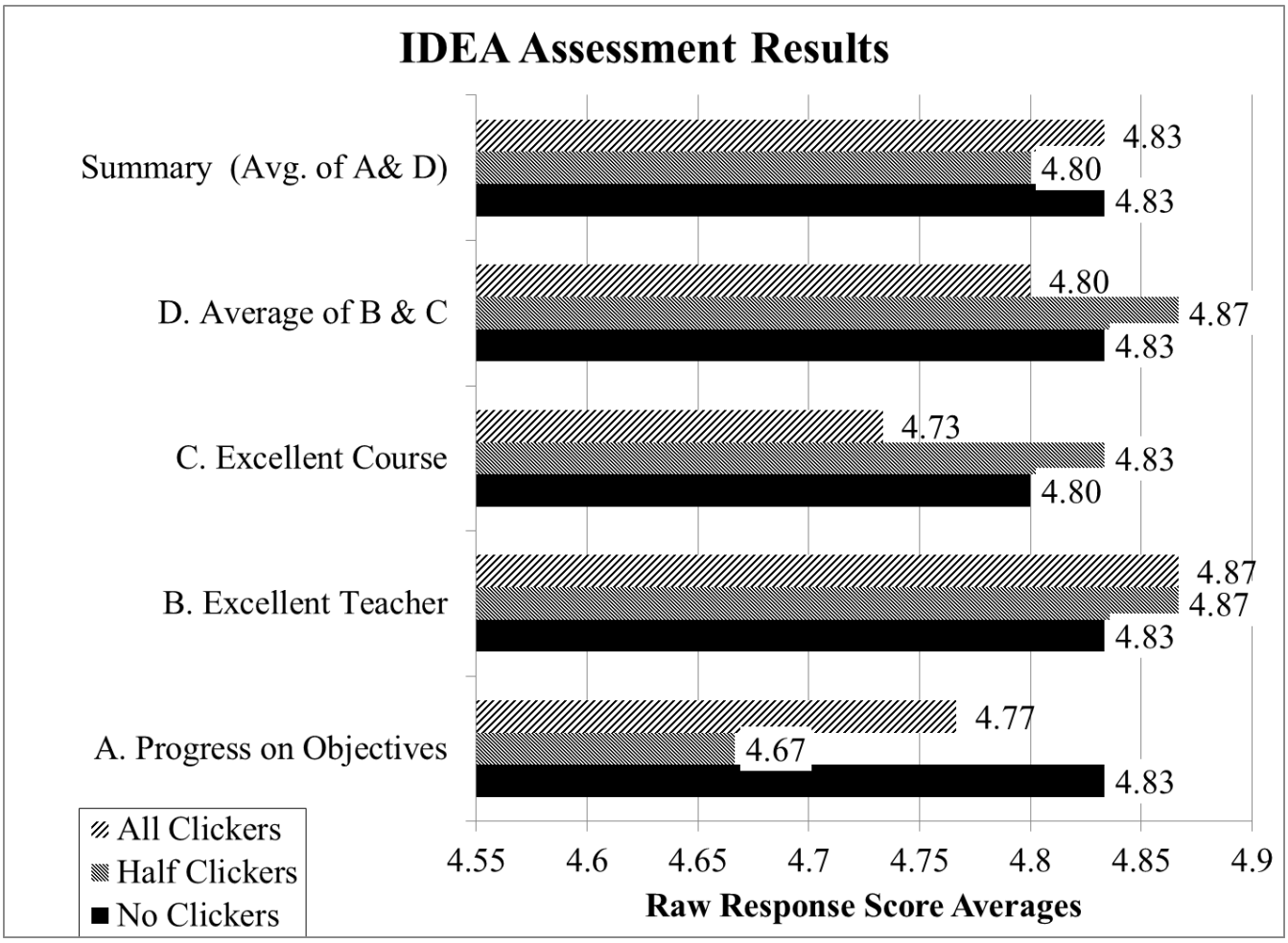

Figure 9: IDEA Assessment Results

Initial Results Utilizing Clickers for Formative Assessment

One of the most important metrics to the authors is the effect of utilizing Clickers on summative assessment results as an indication of overall student learning in each course. Measuring this effect is difficult because each group of students in each course is different, and Fall is different from Spring semester. The method of measuring the effect of utilizing Clickers involves the comparison of summative assessment results in Fall 2010 and Spring 2011 semesters. For each of these semesters, courses were taught with Traditional Homework delivery up to the Mid-Term Exam. Fall 2010 Semester continued with Traditional Homework delivery for the remainder of the semester while the Spring 2011 semester replaced homework with Clicker Quizzes. To normalize the Final Exam results between these two treatments and among multiple student populations, the ratio of final exam scores to mid-term exam scores were calculated. The exams were substantially the same to eliminate exam composition as a variable.

The results show that the Final Exam score ratios are essentially the same for the Clicker-based half-term as for the Traditional half-term. The Junior-level course showed a higher score for the Clicker-based half-term, however the difference is substantially less than one standard deviation and is not statistically significant.

In Fall 2011 semester, students were questioned about their Clicker experience in CNC course. All course students had Clicker experiences from their former courses. The question was the best thing they liked with Clickers. The responses from highest to lowest are

1) Quick assessment response
2) Short time
3) Paperless
4) Easy to use (Convenience)

Students' feedback on the difficulty of the Clicker quizzes is given below:

50%	Tough
41.67%	Moderate
8.33%	Easy

Also, students' satisfaction rate with CNC clickers quizzes was another question. The response rates were given as follows:

83,33%	High
16.67%	Low

The reasons given by the students with low satisfaction originated from the technical issues reported in the upcoming section.

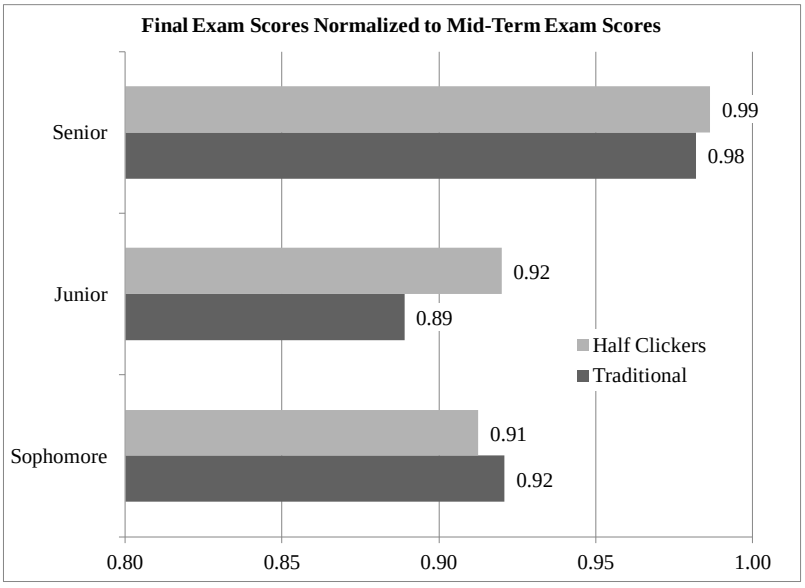

Figure 10: Final Exam Scores Normalized to Mid-Term Exam Scores

Pros and Cons of Utilizing Clickers

The authors feel the strongest advantage to utilizing clickers for quizzes in their courses is the ability to assess learning in real-time. Students' misconceptions may be immediately discussed. The effect of utilizing Clickers for this purpose appears to be as effective as Traditional Homework delivery. Students are engaged in discussion after the results of Clicker questions are displayed.

The disadvantages of utilizing clickers are primarily technical. Often students forgot to bring their clickers to class forcing the instructor to "loan" them one for the quiz. Also, the clicker and receiver must be set to the same channel number. It was easy for students to inadvertently change the channel number causing them to interrupt quizzes to get help from the instructor. Sometimes, the Instructor's PC would fail to recognize the receiver after being inserted into the USB port. This occasionally required a reboot of the PC to correct. To correctly administer quizzes, the instructor must load the questions, the participant list, begin a session, administer the quiz, and then save the session. This process was done incorrectly a few times, requiring the instructor to start-over.

Conclusion

It is the conclusion of the authors that Clickers are a very promising technology to improve student engagement in manufacturing courses. Clickers have now been successfully implemented in eight course-sections in the MIT department at TTU. Both instructors and students respond positively to reviewing questions results in real-time so misconceptions are not carried forward only to be revealed by summative assessment. Student learning is reinforced by the Clicker quizzes. While attendance rates appear to be unaffected, instructors comment that punctuality is improved otherwise students would "miss the quiz."

Students do not like having multiple clicker technologies in various classes. They feel that this is a waste of their money and causes problems remembering how to use Clickers in different classes. The authors recommend that any institution utilizing Clickers should standardize to reduce these problems. Students also prefer the clickers to be provided free due to their lab fees. Some students advised that their quick responses directly linked to the online course management system.

Acknowledgements

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