Use of Educational Technology to Transform the 50-Minute Lecture: Is Student Response Dependent on Learning Style?

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Abstract

Educational technologies like web-deployed assessments and student response systems provide opportunities for formative assessment that would be expected to enhance student learning and help create a more active classroom environment. These technologies can be used in ways that might help or hinder particular types of learners, yet not much research has been done in this area. This paper describes student response to Blackboard™-delivered "preparation assessments" and use of the Classroom Performance System™ in two offerings of a large-enrollment introductory materials science course. The Myers Briggs Type Indicator (MBTI) was used as a measure of learning style, and pre- and post-course questionnaires probed students' reactions. Initial findings indicate that Judging and Perceiving students respond differently to both technologies, and that students with Extroversion preferences tend to react in particular ways to use of CPS. Effects of gender, however, are as or more pervasive than effects of type, and gender and type interact in complex ways.

Introduction and Background

Recent syntheses of the science of learning and assessment of learning have argued for the key role that formative assessment plays in enhancing student learning.[1,2] In this context, formative assessment refers to providing feedback to students *for learning*, versus a summative assessment *of learning*. Increasingly, educational technologies are making it feasible to provide more formative assessment to students in a relatively efficient manner, even in large enrollment courses. This paper describes ongoing experiments in the use of educational technologies in an introductory materials science course. Students are asked to prepare for class by reading the textbook and/or lecture notes and then taking a daily "preparation assessment" via Blackboard™. The questions in these assessments are designed to reveal student misconceptions at a formative stage in the learning process. Fifty-minute class periods are then planned "just in time"[3,4] to bring these misconceptions to the forefront. Short "mini-lectures" are interspersed with frequent use of the Classroom Performance System,[5] a feedback/voting technology or "student response system" that enables instructors to pose questions and problems to students and provide them with immediate feedback on their understanding.

This type of active/interactive classroom experience, along with the expectation to start the learning process on their own via preparation assessments, is novel to most science and engineering students. The dominant model on our campus and many others is still the 50-minute lecture with an expectation of listening and note-taking. While in general students respond well to a more active classroom, there is clearly a spectrum of reactions. This research addresses the question of whether there are patterns in student response according to learning style.

Many learning style models have been used successfully to predict or explain differences in student response to subject matter and to teaching and learning environments.[6,7] One of the more commonly used instruments with an extensive research base is the Myers-Briggs Type Indicator (MBTI), which is based on Jungian theory of psychological type. Only a brief summary of type theory will be given here; interested readers are referred to several articles and books for additional details and explanation.[8-11]

According to Jungian theory, while individuals can typically operate in multiple environments and call upon a variety of skills, each of us has intrinsic preferences or tendencies— ways in which we feel most comfortable when we seek information and make decisions. Furthermore, rather than being random, there are patterns or classifications that are useful in describing the vast range of human behavior. The MBTI groups these patterns into four dimensions, with two possibilities in each dimension:

- Extraversion (E): More interest in the outer world of actions, objects, and persons
  Introversion (I): More interest in the inner world of concepts and ideas
- Sensing (S): More readily perceives immediate, real, practical facts of experience
  Intuition (N): More readily perceives possibilities, relationships, meanings of experience
- Thinking (T): Prefers to make decisions objectively and impersonally
  Feeling (F): Prefers to make decisions subjectively and personally
- Judging (J): Prefers to live in a decisive, planned way
  Perceiving (P): Prefers to live in a spontaneous, flexible way.[8]

Over the past several decades, many studies have shown that some MBTI types tend to struggle in or drop out of engineering programs more than others. These findings are most often explained by mismatches between traditional teaching styles and the learning preferences of many of our students. In general, traditional engineering education is biased towards Introversion (I) over Extraversion (E), Intuition (N) over Sensing (S), Thinking (T) more than Feeling (F), and Judgment (J) over Perception (P).[7,9,12] The majority of engineering faculty tend to be Intuitors, focusing on theory, concepts and principles, while more students tend to be Sensors, perceiving information more readily from practical experience and observation of concrete events. TJ types—methodical, logical, organized— are likely to be attracted and retained well in engineering education, while we are more likely to lose those with F and P preferences-- those who tend to weigh human, subjective factors first and those who prefer to be flexible and spontaneous.[7,9,12]

Rather than being overwhelmed by the notion of providing an ideal learning environment for all 16 possible types, teachers have been advised to use a balanced approach and a breadth of strategies that appeal to each preference at least some of the time.[6] Furthermore, type-conscious instructors recognize that students are also well served by developing modes of learning that come less naturally to them. Often, achieving this balance and breadth can be easier said than done, even with a knowledge of one's own type and openness to a variety of teaching strategies. Indeed, some of my previous research has shown some type-dependence in student performance in one of my introductory materials course offerings.[13] In an effort to achieve and maintain balance in my teaching, I wanted to know whether particular types of students tend to be

enthusiastic or unenthusiastic about, helped by or overwhelmed by, preparation assessments and the use of CPS technology.

Course Description: Use of Blackboard Assessments and Student Response Technology

This paper focuses on two large-enrollment offerings of Introduction to Materials Science, which at Worcester Polytechnic Institute is taught in a seven-week format with four 50-minute lectures and one conference section meeting each week. Students taking this course are quite diverse, from sophomores to seniors and from a variety of engineering and science majors, with some taking the course as a requirement and some as an elective. In this section I will describe how educational technologies were used in each offering of the course, and my expectations as to how students with different learning styles might respond to them.

In the Spring 2004 offering, I used Blackboard-deployed "Reading Quizzes" for the first time, in an attempt to promote preparation for class so that class periods could be used primarily for additional assessment and feedback rather than information delivery. Because of the large enrollment (113) and only one TA, a multiple-choice format was used, which could be graded automatically by the system. Each reading quiz had five questions addressing key concepts from the assigned reading, and students had to complete the quiz on-line no later than several hours before class. In an attempt to decrease inappropriate student collaboration (i.e., copying), upon completion of the quiz students could see their score but not which answers were correct/incorrect. After the quiz deadline had passed, answers were made available on the Blackboard site. These reading quizzes contributed 10% to the overall course grade, but each student was given two "freebies" (i.e., two quizzes that could be missed without an effect on their grade.) I reviewed the quiz results prior to class and addressed common misconceptions. Note, however, that these reading quizzes were really summative in nature; students' state of understanding from the reading was graded for its correctness.

In the Fall 2004 offering of the course, there were slightly fewer students (95) and two TAs, so I transformed the quizzes into formative "Preparation Assessments" that were intended to be assessments *for learning* instead of assessments *of learning*. There were two open-ended questions on each assessment, and an optional "Muddiest Point" question. Following is an example of the assessment used for a class meeting on basic mechanical behavior:

1. Explain the difference between elastic and plastic deformation. What is the property that indicates a material's resistance to elastic deformation, and what is the property that indicates a material's resistance to plastic deformation?

2. Sometimes we just refer to the "strength" of a material, but it's important to distinguish between different strength properties. *What is the difference between yield strength and tensile strength?* Try to think of and describe an application where you would be most concerned about the yield strength (in other words, not exceeding that stress level) and a situation where you'd actually want to be operating above the yield strength but below the tensile strength.

These questions are typical in that most tended to be conceptual in nature, helping the students identify the "big ideas" in the reading that we would be focusing on in class. Example responses were distributed in each class, showcasing both good responses and common misconceptions without revealing the identity of the authors. A TA graded student responses to the questions using a three-level rubric that focused on completeness and clarity of thought rather than whether it was correct. Again students were given two "freebies" in the event that they forgot to take one of these daily assessments.

The Classroom Performance System™ (CPS) wireless response technology was used in the same manner in the Spring and Fall offerings. Each student signed out a response pad ("clicker") at the start of the course. In each class period, I would typically pose two to three multiple choice questions or problems intended to reveal common misconceptions, often in a "think-pair-share" format and, whenever possible, focusing around a demonstration. The system records student responses and projects them onto the screen in the form of a histogram. Students were graded on their participation, not whether their answer was correct. This participation in "in-class problems" contributed 10% toward the overall course grade. Again, students were given two "freebies" in the event that they forgot their clicker.

How might these daily preparation assessments and in-class problems be perceived by students with different learning styles? I expected that Perceiving students might struggle on the preparation assessments, since it was a daily deadline to meet—not at all aligned with their preference for flexibility. I thought that Sensing students might respond more positively to the multiple choice reading quizzes in the Spring offering, while Intuitive (N) students might prefer the open-ended conceptual questions in the Fall offering. Performance on in-class problems via CPS is obviously tied to attendance, so I was interested to see whether any types of learners particularly struggled to get to class. I also hypothesized that Extraversion and Sensing preferences, often underserved in traditional classrooms, might particularly enjoy using CPS. Extraverts may appreciate use of CPS as a form of outward expression, the sense of community it can create, and the opportunity to discuss things in class. Sensing students may particularly benefit from seeing their responses and knowing immediately if they answered a question correctly. A classroom research study was conducted to test these hypotheses.

Research Methods

Student reactions to the preparation assessments and use of CPS were gathered via an end-of-course questionnaire that addressed many additional aspects of the course and a variety of student attitudes. Bonus points toward their grade were given as an incentive for completing the questionnaire. Questions were designed to reveal student perceptions about the usefulness of preparation assessments and in-class problems. More specific questions about CPS were designed to provide some insight into reasons *why* the students may respond well, or not, to its use. (Many of the CPS questions were adapted from a questionnaire distributed by instructors at the University of Notre Dame.) In addition, students' grades for the preparation assessments and in-class CPS problems were compiled.

As previously explained, the Myers-Briggs Type Indicator (MBTI) was used as a measure of students' learning style. For the Spring 2004 course offering, MBTI data were mined exclusively

from a pre-existing university-wide archive. (For a four-year period, the MBTI Form M was administered to first-year students during New Student Orientation and was scored by certified individuals.) Type data were available for about 50% of the students in my Spring 2004 course. MBTI data were then linked to questionnaire and grade data via student ID numbers. The combined population of students for whom both MBTI and questionnaire data were available was statistically representative of the whole on the basis of final average and grade distribution.

For the Fall 2004 course offering, archived MBTI data were available for fewer students, so anyone whose type was not already in the archive was asked to complete Form M on a web site administered by CPP, Inc. (www.cpp.com). The results were scored electronically by CPP. Again bonus points were offered as an incentive for completion. As recommended for MBTI testing, students were encouraged to attend a feedback session to verify and learn about their type, but data were not altered based the results of feedback sessions. In this manner, MBTI data were obtained for 81% of the students in the Fall offering. The combined population of students for whom both MBTI and questionnaire data were available, however, was only marginally representative of the entire class; non-respondents had a lower final average (p=.02) and lower letter grades (p=.37) than respondents.

Exploration of the questionnaire results and grades for preparation assessments and in-class problems showed that most of the data were not normally distributed about a central mean. For that reason, non-parametric statistical methods were appropriate. The Mann-Whitney test, the non-parametric equivalent of an independent-samples t-test, was most frequently used. In this test, the data for the dependent variable are ranked from lowest to highest, and then mean ranks are compared for different groups.

Beyond the limitation associated with a marginally-representative sample for the Fall 2004 offering, it is important to acknowledge some additional limitations of this research design. Although analysis of variance (ANOVA) with multiple independent variables (e.g., MBTI dimension, gender, course offering) was used in an exploratory fashion, equivalent non-parametric methods are not available. Therefore, most of the results reported here look at isolated effects of those independent variables. In reality, multiple variables are sure to interact in complex ways. For the most part, the results reported here should be viewed as trends and hypotheses that should be tested with more detailed analyses, which will be reported elsewhere.

Results and Discussion

Table 1 shows student ratings of the effectiveness of reading quizzes (Spring 2004) and preparation assessments (Fall 2004) in promoting preparation for class. The more formative, open-ended assessments were rated as being more effective (p=.05). There were no significant differences in responses between students who had E-I, S-N, T-F, or J-P preferences. Therefore, the hypothesis that Sensing students would be more drawn to the multiple choice assessments and Intuitive students to the open-ended conceptual questions was not supported. The different response to the two types of Blackboard assessments is almost entirely due to males, however, who comprised about 80% of both classes. With males and females considered separately, females rated the two types of assessments virtually identically (p=.97) whereas males who

Table 1: Comparing the Effectiveness of Two Different Types of Blackboard-Deployed Preparation Assessments in Promoting Preparation for Class							
Term	% Responding*					Mean** (Mean Rank)	*p*
	1	2	3	4	5		
Spring 2004 (N=103) *Multiple choice summative*	4.9	9.7	16.5	53.4	15.5	3.65 (86.6)	.052
Fall 2004 (N=82) *Open-ended formative*	3.7	6.1	17.1	41.5	31.7	3.91 (101.0)	

* Students rated their level of agreement with the statement "Reading quizzes / Preparation assessments were effective in promoting preparation for class," on a scale of 1= Strongly disagree; 2= Disagree; 3= Neutral; 4= Agree; 5= Strongly agree

**Means are reported only for purposes of illustration. The Mann-Whitney test, which analyzes mean ranks instead of means, was used as the test for significance.

completed the open-ended formative assessments rated them as more effective in promoting preparation for class than did males completing the multiple choice quizzes (p=.037).

Although there was no significant difference between J and P students' ratings of the effectiveness of preparation assessments in promoting preparation for class, their grades for that aspect of the course were significantly different. In other words, while students may have agreed that the assessments *promoted* preparation, their actions did not always follow. As expected, Ps tended to struggle to keep up with these daily assessments, but gender and the type of assessment were influential factors as well. Table 2 shows that gender is the dominant effect; females strongly outperformed males in both offerings. For males, there was no difference between Js and Ps for the multiple choice, summative assessments, but Js outperformed Ps on the open-ended formative assessments (p=.023). For females, the effect was inverted: Js outperformed Ps in the multiple choice assessments (p=.077), but the difference reversed for the open-ended formative assessments, although the latter difference lost statistical significance. A possible explanation for the lack of a J-P difference for males in the Spring offering, but a strong J-P difference in the Fall offering, is that the multiple choice assessments seemed less of a barrier;

Table 2: Effect of Judgment-Perception Preference and Gender on Mean Reading Quiz / Preparation Assessment Grades*						
	Spring 2004 Multiple Choice Summative			Fall 2004 Open-Ended Formative		
	J	P	Total	J	P	Total
Females	93.6 *(6)*	84.5 *(9)*	88.1	85.9 *(8)*	92.3 *(5)*	88.3
Males	77.1 *(17)*	77.7 *(17)*	77.4	86.3 *(24)*	76.0 *(36)*	80.1
Total	81.4	80.0	**80.7**	86.1	78.0	**81.6**

*(*Numbers in parentheses)* are numbers of students in that category. Although means are reported for ease in understanding, means were not used in statistical tests since the grade distribution was not normal.

they can be done more quickly and with less planning. It is not immediately clear, however, why females would not react in the same way. The difference between male and female Ps is striking, and this effect becomes a pattern that is worthy of more investigation. Aside from the J-P dimension, there were no other type-dependent effects on preparation assessment grades.

Several questions on the end-of-course questionnaire asked students to respond to statements about how the use of CPS influenced them. Results are shown in Table 3, with data from the two offerings combined since CPS was used in the same way. The data suggest that students like how CPS enables them to see how their peers are thinking, and that they also appreciate the feedback on how they are understanding the course material. In addition, students acknowledged that they were less likely to skip class because of CPS, although it's not clear whether that was because the in-class problems were part of their grade or because they enjoyed the more active class environment.

Table 3: Insight into Student Response to Classroom Feedback Technology*

	Mean	Std. Dev.
I liked how the CPS technology allowed me to see what my classmates were thinking.	3.85	.97
I was less likely to skip class since I knew that we would be using the clickers.	3.85	1.15
When we used CPS, I received valuable feedback on how well I understood the course material.	3.77	.93
The CPS system helps me feel more connected with the instructor.	3.35	1.01
Since I knew I'd be asked to answer questions with the clicker, I tended to pay more attention in class than I normally would.	3.29	1.01

*Students rated their level of agreement with each statement on a 5-point Likert scale: 1= Strongly disagree; 2= Disagree; 3= Neutral, 4= Agree; 5= Strongly agree. These questions were adapted from a questionnaire about CPS used by the University of Notre Dame.

There were few type-dependent differences in students' attitudes about CPS, with the exception of the Extraversion-Introversion dimension, as shown in Table 4. Extroverts more often cited the effect of CPS in helping them come to class and pay attention once they were there. This result reinforces the notion that Extroverts disproportionately struggle with 50-minute passive lectures. Interestingly, Extroverts more often saw CPS as a way to connect with the instructor, which speaks to the value of CPS especially in large courses. While the E-I effect shown in Table 4 decreases when gender is introduced as a co-variate, the E-I difference remains dominant. Note that the hypothesis that Sensing students might have more positive feelings about the use of CPS was not supported.

Even though Judging and Perceiving students had similar attitudes about CPS, their performance on in-class problems differed, but again there are complex interactions with gender (Table 5). Js outperform Ps, but only uniformly for males. Perceiving females show the same or higher performance as Judging females. Recall that the grading of these in-class problems is entirely

Table 4: Effects of Extraversion-Introversion Preference on Response to CPS Technology			
	Mean and (Mean Rank)*		
	E *(N=49)*	I *(N=68)*	*p*
Tended to pay more attention in class.	3.69 (71.1)	3.09 (50.3)	.001
Helps me feel more connected with instructor.	3.60 (67.3)	3.10 (52.3)	.014
Less likely to skip class.	4.04 (66.6)	3.63 (53.5)	.030

* Students rated their level of agreement with each statement on a 5-point Likert scale. Means are reported here to give a sense of student response, but mean ranks are used in the Mann-Whitney test.

Table 5: Mean Grades for In-Class Problems Deployed by CPS*						
	Spring 2004			Fall 2004		
	J	P	Total	J	P	Total
Females	90.6 *(6)*	*90.2 (9)*	90.4	91.7 *(8)*	94.3 *(5)*	92.7
Males	92.7 *(17)*	85.1 *(17)*	88.9	95.1 *(24)*	82.5 *(36)*	87.5
Total	92.2	86.8	89.4	94.2	83.9	88.5

**(Numbers in parentheses)* are number of students in each category. Although means are reported here for purposes of illustration, mean ranks were used in statistical analyses since the grade distribution was not normal.

Table 6: Overall Student Perspective on Effectiveness of CPS Technology						
	% Responding (N=185)*					Mean
	1	2	3	4	5	
Use of CPS was effective in promoting thinking and active learning during class.	2.2	5.4	42.2	50.3	--	3.41
I recommend continued use of the CPS technology.	2.7	2.2	8.1	38.9	48.1	4.28

*Because of an artifact related to when these questions were introduced in various offerings of the course, a 4-point Likert scale was used for the first question (no neutral position), while a 5-point Likert scale was used for the second question. The highest and lowest numbers on each scale are Strongly Agree and Strongly Disagree, respectively.

formative in nature; students are given full credit if they "click-in" an answer, regardless of whether the answer is correct. It seems that regular class attendance is more of a barrier for male Perceiving students than for female Perceiving students. Note, however, that on the whole, class attendance was quite good, around 90%.

Another point to emphasize is that the overall student response to use of CPS was quite positive, as shown in Table 6. A plurality of students in the two course offerings strongly agreed that CPS was effective in promoting thinking and active learning during class, and strongly agreed that use of CPS should be continued in the course. Furthermore, there was no type-dependence or gender-dependence in student response to those questions. So while student attitudes about CPS are balanced according to their learning style, type-dependent outcomes may result if it is used in the grading process. At the same time, students acknowledge the value of CPS in promoting attendance, and that incentive would likely disappear if student responses were not recorded as part of a participation grade.

Summary

Overall, student response to technology-assisted classroom assessment has been positive and met instructional goals. Conceptual, open-ended formative assessments deployed on Blackboard were rated by students to be more effective than multiple choice assessments in promoting preparation for class. In addition, CPS technology received broad, strong support for promoting an active classroom environment, and class attendance was quite high, usually between 80-90%. In combination, the preparation assessments and in-class problems enable contact time with the instructor to be used in more effective ways than a traditional 50-minute lecture.

Student reactions to this transformation of the 50-minute lecture did not show as many learning-style dependent responses as was hypothesized. That is good news; one would hope that these modifications would benefit all types of students. However, this research has shown several type-dependent effects of Blackboard-deployed assessments and use of student response technology (CPS):

- As hypothesized, there was a J-P difference. Male Perceiving students struggle more than male Judging students in completing daily preparation assessments and coming to class. This difference does not hold true for females, however. Effective strategies need to be developed for motivating and assisting male Ps and helping them take advantage of formative assessment opportunities.

- CPS technology received broad support from all MBTI types, but compared to Introverts, Extroverts disproportionately cited its effectiveness in promoting attendance and attentiveness, and in helping them feel more connected to the instructor. This finding supported a hypothesis that Extroverts might particularly enjoy using CPS. Thus, the use of CPS technology to promote an active classroom environment may have particular value for Introverted instructors, who are dominant among engineering faculty and who otherwise may have difficulty engaging Extroverted students.

It is not clear whether these results can be generalized to other educational settings or to somewhat different uses of the technology for formative or summative assessment. If similar findings were revealed at other institutions, changes in instructional practice and uptake of these technologies may proceed more rapidly.

This paper began with the premise that use of Blackboard and CPS technologies facilitates formative assessment, which in turn may enhance student learning by identifying and confronting misconceptions earlier in the learning process. This research did *not* show whether that potential benefit of formative assessment was actually realized. Analysis is underway to compare students' progression in formative assessment exercises with final summative measures of learning for particular concepts in the course. With that information, the benefits of formative assessment may be demonstrated more directly, or it may become evident that modifications of the formative assessments or other aspects of course instruction are necessary.

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