Using smartphones for formative assessment in the flipped classroom

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ABSTRACT

Flipped classrooms are by design highly interactive. As a result, formative assessment is a necessary component of the flipped classroom. Professors need to be able to assess students' in the class, use this assessment information to inform classroom activities in real time and personalize learning for their students. One way to integrate formative assessment in the flipped class is with the use of smartphones. This paper describes strategies used to effectively incorporate smartphones into the classroom to enhance teaching and learning. Examples of innovative teaching practices to improve student understanding and performance using a classroom response system app are provided. Ways to capitalize on the benefits and minimize distractions from smartphone use are discussed. Data from exit surveys administered to assess students' perception of mobile technology effectiveness in the classroom are also reported. Results suggest that using this technology enhances student understanding of course concepts. Using the strategies outlined in this paper, professors will gain insight into students' understanding of course materials and these insights could be used to guide current and future lesson plans.

Keywords: student engagement, classroom response systems, flipped classroom, peer instruction, smartphones, socrative.com
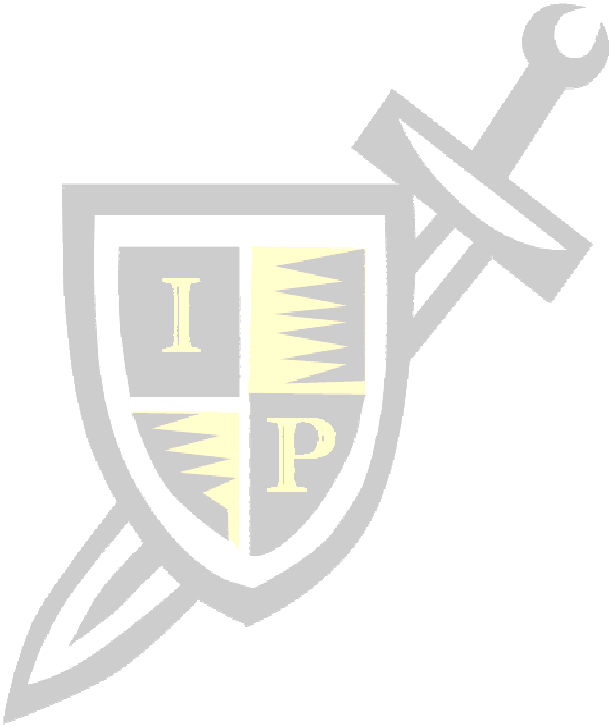
INTRODUCTION

The use of Classroom response systems (CRS) such as clickers in the college classroom setting have much benefits as proven by many studies (Hatch, Murray, & Moore, 2005; Caldwell, 2007; Lantz, 2010; Lantz & Stawiski, 2014). In the classroom, smartphones can be used as a CRS and they can be an asset when intentionally incorporated to enhance and support student learning.

This paper demonstrates, focuses, outlines and discusses:

- How the use of mobile technology in the classroom can be an asset rather than being a liability.
- How smartphones can be used as a learning tool for formative assessment.
- The pros and cons of the use of mobile device in the classroom and steps to take to capitalize on its benefits and minimize distractions.
- Data from exit surveys administered to assess students' perception of the effectiveness of using mobile technology in the classroom.
- The use of an app which allows students to sign up to receive text reminders from their professor as well as methods in which it is used to support student learning to keep students organized.
- Results from data collected from economics courses, which suggest that using technology enhances student understanding of the material being taught. Pre- and post-quizzes taken during each class period using a CRS app show gains in student understanding of the course content throughout the semester. There's an overall positive students' views and perceptions of CRS use in the classroom.

CLASSROOM RESPONSE SYSTEMS (CRS)

The use of technology in the classroom has been demonstrated to increase motivation to attend class (Onodipe & Ayadi, 2016), and this could translate into motivation to learn the material and receive better grades. When students are able to use technology to engage in instruction and complete quizzes and assignments, they are more motivated to do so because the use of technology has the novelty factor when compared to the traditional learning environment.

In recent years, CRS use in economics college classrooms increased (Liu, Walker, Bauer, & Zhao, 2007; Bergstrom, 2009; Calhoun & Mateer, 2012; Mohr, 2013; Hayter & Rochelle, 2014; Olney, 2016). They have been used for peer instruction (Mazur, 1997; Ghosh & Renna, 2009; Salemi, 2009), student opinion surveys and comprehension checks (Onodipe & Ayadi, 2016). CRS have been used to improve the effectiveness of teaching and learning in various classroom settings and have been shown to improve student achievement when coupled with appropriate pedagogies such as ConcepTests (Mazur, 1997), Just-In-Time Teaching (Sevian & Robinson, 2011), Interactive Lectures and Cooperative Learning (Fies & Marshall, 2006). A meta-analysis study showed that when students use clicker technology in classrooms they are able to better receive the information that is being taught and understand it (Hunsu, Adesope, & Bayly, 2016). Higher levels of competency in the form of higher scores were found in students when they used clickers versus students engaging in discussion (Adams & Columba, 2014).

SMARTPHONES IN THE CLASSROOM

Nowadays, Bring-your-own-device (BYOD) systems allow students to use devices they already own (e.g., a smartphone, tablet or laptop) to answer quiz questions in the classroom (Imazeki, 2014; Onodipe, 2017). There are benefits and costs to allowing smartphone use as a CRS in the classroom (Cheng, Guan, & Chau, 2016). In Wash (2014), student survey data indicate that using smartphones in the classroom increases student participation, helps provide instant feedback on what students know, and increases mental engagement in class. While Green (2016) showed that the use of smartphones in the classroom improved exam performance by over 8 percent in a principles of economics classroom.

Education research has provided other ways to incorporate smartphones into the classroom. Some possible ways smartphones can be used in the economics classroom include social media. Kassens (2014) describes how Twitter was used as a complement to the traditional lecture in a macroeconomics course. According to this study, Twitter develops reflection and writing skills and expands the class community. Al-Bahrani and Patel (2015) discuss the potential benefits of incorporating social media such as Twitter, Instagram, and Facebook inside and outside of the classroom. Dowell and Duncan (2016) discuss using Periscope to live stream video footage of their current location and to have text conversations between members around the globe in real time.

Podcasts are another way to use smartphones in the classroom. Moryl (2013) used publicly available economic-themed podcasts in an introductory economics courses and found that students with auditory/verbal learning styles improve their understanding and application of economic concepts more than students with other learning styles. A study by Berk (2009) discusses the potential value and uses of video clips in the college classroom. These benefits include increased memory of content, comprehension, understanding, and deeper learning.

Despite the benefits of smartphone use in classrooms, professors have reservations about allowing students to use their smartphones in class because of the potential for distraction. Using a smartphone instead of a clicker opens up the opportunity for students to get distracted by what else smartphones have to offer, such as emailing, social media, texting, and surfing the web for non-class related sites. Ma, Steger, Doolittle, and Stewart (2017) showed that 62 percent of students were distracted within 5 minute of an in-class cell phone activity, while Steger, Doolittle, and Stewart (2017) showed grades did not improve significantly on quizzes when students had access to cellphones in class. End, Worthman, Mathews, and Wetterau (2010) report that a ringing cell phone in class negatively affects student performance. Steger, Ma, Doolittle, & Stewart, (2017) investigated students' persistence in their use of cellphones for non-class reasons (e.g., texting, emailing, web surfing) following the use of their cellphones for class reasons (i.e., answering professor questions). They found that over half of the students were distracted within 5 minutes of a cellphone activity for academic purposes.

Pairing the use of smartphones with student-centered instructional approaches (e.g., flipped classroom and peer instruction) can further capitalize on the instructional power of mobile supported CRS systems in the classroom (Onodipe, 2017). When smartphones are used correctly in class, they can improve student engagement and may not be a deterrent to student learning. Peer instruction is an interactive teaching technique in which students are asked multiple-choice conceptual questions during class. Students then partner with their peers during class to explain the concepts with one another and to come up with the correct responses to the question. This teaching technique was popularized by Eric Mazur of Harvard University. Peer

instruction works on the theory that students at similar cognitive levels can at times explain content where educators may experience the "expert blind spot" (Wiggins & McTighe, 2006).

There are various types of applications available to make smartphone use in the classroom more effective - TopHat, Socrative.com, Padlet, Ombea, Kahoot, PollEverywhere, Quizalize, Formative – to name a few. Many of these apps are free and have essentially the same features. They all increase student engagement, are relatively easy and fun to use, and provide formative feedback to the professor. While any one of them would have worked for this study, Socrative.com was selected as the classroom response system app. This was used in conjuction with the flipped classroom model which involves peer instruction.

These strategies are being used in several Principles of Economics courses at a 4-year public open access college in the southern United States. The demographic composition of one typical class is indicated in Table 1 (Appendix). The class consisted mostly of traditional students (92 percent), meaning they enrolled in college immediately following completion of high school and under the age of 25. Forty three percent of them were freshmen and sophomores were about 47 percent, while slightly over half were male (54 percent). Class size was 35 students.

STRATEGIES FOR INCORPORATING SMARTPHONES IN THE CLASSROOM

One obstacle which professors face in trying to conduct formative assessments, classroom assessment techniques, or surveys, to get the pulse of the class, is the time required to grade and analyze the feedback. The CRS app used collects and summarizes the data in a spreadsheet. This section provides examples to illustrate how smartphones can be effectively used in the classroom for this purpose.

Formative Assessment: Just-In-Time Teaching, and Comprehension Checks

Smartphones can be used in the classroom for formative assessment. Quizzes conducted in class during the learning process are useful to the professor because they provide a chance to determine what students understand and where there is confusion. Armed with this information, the professor can modify teaching activities to improve student learning.

The flow chart of the course structure in a flipped classroom is indicated in Figure 1 (Appendix). As pre-class work (PCW) in this flipped class, students were required to read a chapter of the textbook, review PowerPoint slides, watch a short (5-7 minute) instructional video, and complete a simple pre-class work assignment due for submission before class. As students arrive in class on class day, they complete a 4-question multiple-choice pre-quiz on their smartphones or mobile devices using the CRS app. This gives the professor an idea of how much students learned from their preparation before coming to class. Results are immediately available to the professor. Then, the percentage of correct responses is shown to the class, however, the correct responses are not yet revealed. Based on the results, a brief overview of the concepts is provided, misconceptions are clarified, and questions answered. The submissions of the PCW and pre-quiz grade results provide an opportunity for just-in-time-teaching (JiTT).

If less than 30% of the class got the pre-quiz question correct, it would be clear that they did not fully understand the concept being questioned and the topic needs to be clarified before going into in-class activities (Thirty percent is a rule of thumb used by Salemi and Vasquez (2011)).

Following the review of the pre-quiz results, if between 30 and 85% of the class gets the pre-quiz question correct, this is an opportunity to engage in peer instruction. An in-class activity handout is distributed. A demonstration of how to work through some assigned problems is provided, and the students are then allowed to work through other similar problems in groups using peer instruction. Mazur (1997) states that students get the most benefit from peer discussion when about 30–70% of the class answers the ConcepTest correctly before discussion. While students complete the handout, the professor moves around the room interacting with students, listening to their discussions and providing on-the-spot feedback. If more than 85% of the class got this question correct, the professor proceeds to in-class activities to delve deeper into this topic. In-class activity would then involve discussing more scenarios to distinguish change in demand from change in quantity demanded, illustrating these changes in demand on a curve, and determining the new equilibrium price after a shift has occurred.

Finally, towards the end of the class, the concepts are debriefed and put in context, and the chapter is wrapped up. Then, students take the same or similar multiple choice post-quiz. They are allowed to confer with group members and change their answers. At the end of the post quiz, answers are revealed and overall quiz answers are publicized. Students are able to note the difference between their pre- and post-quiz grades.

Test Reviews: Muddiest Point Quizzes and Mock Tests

Another use for smartphones in the classroom is during test review time. One way to provide a more targeted study session before a test is to create a quiz in the app listing all topics that will be on the test and asking students to check which ones they do not fully understand. This is called a muddiest point quiz and it gives the professor a better idea of which topics students collectively need further review on. This type of immediate feedback gives the professor information that will be useful in making the review session more effective and geared towards what students do not understand.

The results from a Muddiest Point Quiz in the course is indicated in Figure 2 (Appendix). From this quiz, it was clear that majority of the students had a good grasp of the material. Only 5% of students selected "Taxes" as the muddiest point. The largest area of confusion was "Alternative Methods of Allocating Scarce Resources (14%). By the end of the review session, much of the confusion would be clarified.

During the review session, students are given a practice test to get a sense of how well they will perform on the actual test. Feedback from the practice test gives an indication of which types of questions will be on the actual test. It also allows students to get more practice solving problems with no burden placed on the professor to grade. As students work through the mock test and enter their answers, the professor walks around the groups and addresses wrong answers.

Students also get an opportunity to confer with their peers on challenging questions. This increases professor-student interaction as well as student-student interactions.

Critical Incident Questionnaires (CIQs)

CIQ is a five-question form that students fill out in class several times during the semester. Critical incidents are brief descriptions of vivid happenings that for some reason people remember as being significant (Brookfield, 2017). The five CIQ questions are indicated in Table 2 (Appendix). Students spend three to five minutes filling these out at the end of a given

class period. Responses from CIQs usually provides a common theme – for example, an area of confusion. The CRS app can be used to easily complete CIQs. Individual comments that are striking are easily noted. At the next class meeting, a brief summary of the responses is discussed with the class. A summary of CIQ results are shared at the start of the next class period or on the 1st day of class the following semester as "tips from predecessors".

Exit Ticket Survey

Exit surveys allow the professor to ask students questions at the end of a class period to gather information about what students learned and how much they understood the lesson. Some CRS apps have built-in exit ticket questions such as:
1) How well did you understand today's material? (With three response options: Totally got it; Pretty well; Not at all);
2) What did you learn in today's class? (Students have a chance to give a short open-ended response to this question). The report from an Exit Ticket survey is indicated in Figure 3 (Appendix). It shows 100% of the students stated that they either totally got today's material or understood the material pretty well (46% and 54% respectively).

Test Prep Checklist

A modified test preparation checklist (Felder 1999) was administered to students before tests as a prompt of things they need to do to succeed in a flipped class (Table 4). A CRS app can be used to make this task easy to complete and less of a burden for the professor to analyze. Results from a test prep check list done before a test are indicated in Figure 4 (Appendix) and they reveal that every "Yes" response adds 8.8% to student score. A student that has nine Yes responses could earn 91% on the test while a student with five Yes responses or less could potentially earn less than 60%. This type of analysis shared with students could motivate them to put in the time and effort to read the textbook, participate in class, attend review sessions, and have as many true Yes responses as they can in order to achieve their desired grade.

Communication/Organization

To improve the efficiency of the time spent in a flipped class, Talbert (2017) suggests streamlining or eliminating course announcements in class. Text message has become students preferred mode of communication (Hochstrasser, 2014). Rather than communicate these announcements with students via email messages or posting announcements through the university's Learning Management System (LMS), greater success at reaching students can be achieved via text messaging. Remind.com is a smartphone-enabled app, a communication tool which allows students to sign up to receive text reminders from their professor about upcoming deadlines for assignments, important dates and reminders to students through text, which is the preferred mode of communication of millennials. It is used to keep students engaged and on track after class time is over. Students use it to reach out to professor for individual help; the professor can use it to extend learning beyond the classroom; last minute changes to the course schedule can be communicated to students, and the professor can motivate students and remind them of upcoming assignment due dates.

Once students join the class via Remind.com, they receive texts sent from the professor to their smartphone. The texts must be within 140 characters in length.

The app was used to provide reminders about deadlines and reminders. For example:

- "For Monday's class, read Ch 7, review PPT slides, & watch Videos. We'll be reviewing TAXES, PRICE CEILINGS & PRICE FLOORS this week."
- "Test #3 is on Monday. Please review Ch. 6, 7, and 8 in preparation for the test. Mock Test and Study Guide are on D2L."
- "Please submit Ch. 14 PCW to D2L drop box before class on Wednesday."

It can also be used to provide motivational messages:

- "Test #2 grades are in. Check D2L. GREAT JOB!! I am pleased with overall class average (80%). We'll discuss further on Monday. On to Ch 4 ..."
- "For Test #4 tomorrow, bring: Scantron and Pencil. Good luck studying!"

FEEDBACK FROM STUDENTS

Exit surveys administered at the end of the semester reveal that students find pre and post quizzes to be very useful. Comments from students on the exit survey include:

- "I did almost all of the pre and post quizzes which helped immensely."
- "Showing up for each test review helped enhance my learning."

In response to the question "Rate how beneficial taking Pre and Post Quizzes was to you in this course," over 88% of students strongly agreed or agreed that this is beneficial. In response to the question "Rate how beneficial Mock Tests/ Review Sessions was to you in this course," over 97% of students strongly agreed or agreed.

Using a five-point Likert Scale ranging from 1 (strongly disagree) to 5 (strongly agree), the students were asked questions about quizzes. The survey questions about students' experience using the app are indicated in Table 3 (Appendix), while the results from the survey are indicated in Figure 5 (Appendix). Eighty six percent of students strongly agreed or agreed that the app was easy to use. Seventy five percent stated that it helped reinforce important concepts, and provided instant feedback, and would recommend it be used in other courses taught at the institution because it helped gauge their understanding and improved their performance in class. They also agreed that the app increased their desire to attend class and willingness to ask questions in class. Over half of the students said it made class more enjoyable and increased their interaction with peers.

In response to the CIQ, "What actions by the teacher have been the most affirming or helpful?" students responded as follows:

- "Working independently and then grouping up with classmates. Also allowing us to take pre- quiz at the beginning of class to see what we know, and then re-doing it to see if it was clarified or understood better."
- "She makes sure we are all paying attention."
- "Having mock tests to hammer in the info."

While Socrative app was used for this study, similar responses would be obtained if any of the other apps were used for formative assessment in the classroom.

. Feedback from students about the usefulness of remind.com to their success is as follows:

- "I never check my email but I do check my texts so the updates via text message from my teacher helps a lot"
- "It prepared me and reminded me of any assignments or changes immediately."
- "It reminded me to keep an eye on my schoolwork, kept me on track throughout the week, and ensured that I knew what must be done before class in order to perform at the best of my ability."
- It helps me keep up to date with things, so when I look at my phone whatever I've just been reminded of is stuck in my mind."

LESSON LEARNED AND CONCLUSIONS

Some lessons were learned from using a CRS on smartphones in class. The discussion that follows after a quiz is very important. Students are asked to explain why they chose a certain answer over another and why a particular answer is right or wrong. Even with multiple-choice questions, they are required to give reasons why they chose a particular answer. This engages students even further with the content. All students participate in class, even the introverts and the students who are not fluent English speakers. With the CRS, it is easier to identify those who understand the material and those who are lost. The professor can then follow up with individual students who got the answer wrong or call on students who got the answer correct and have them explain their answers to the class.

Allowing students' time to take the quiz, shutting down the quiz, and announcing that all phones be put away, minimizes the possibility of students getting into off topic sites on their mobile devices while in class. There is a set time when smartphone use is allowed and once the app has been closed, an announcement is made to put phones away. Smartphones do not come back out again until the end of class when it is time to take the post quiz.

Given that a flipped classroom requires students to participate in learning activities prior to class such that the classroom time can be used more effectively, combining the use of smartphones in the classroom with flipped learning and peer instruction has the potential of enhancing active learning. Exit survey results suggest that these approaches increase student understanding and enhance active learning in the classroom. The use of smartphones allows more frequent assessment of students without it being a burden on the professor's time even in a traditional class setting.

Six ways of using these apps effectively were discussed in this paper. They include: formative assessments; test reviews, critical incident questionnaires, exit tickets, test prep checklists, and effective communication with students through remind.com. Further research into the impact of each of these on student achievement are being done.

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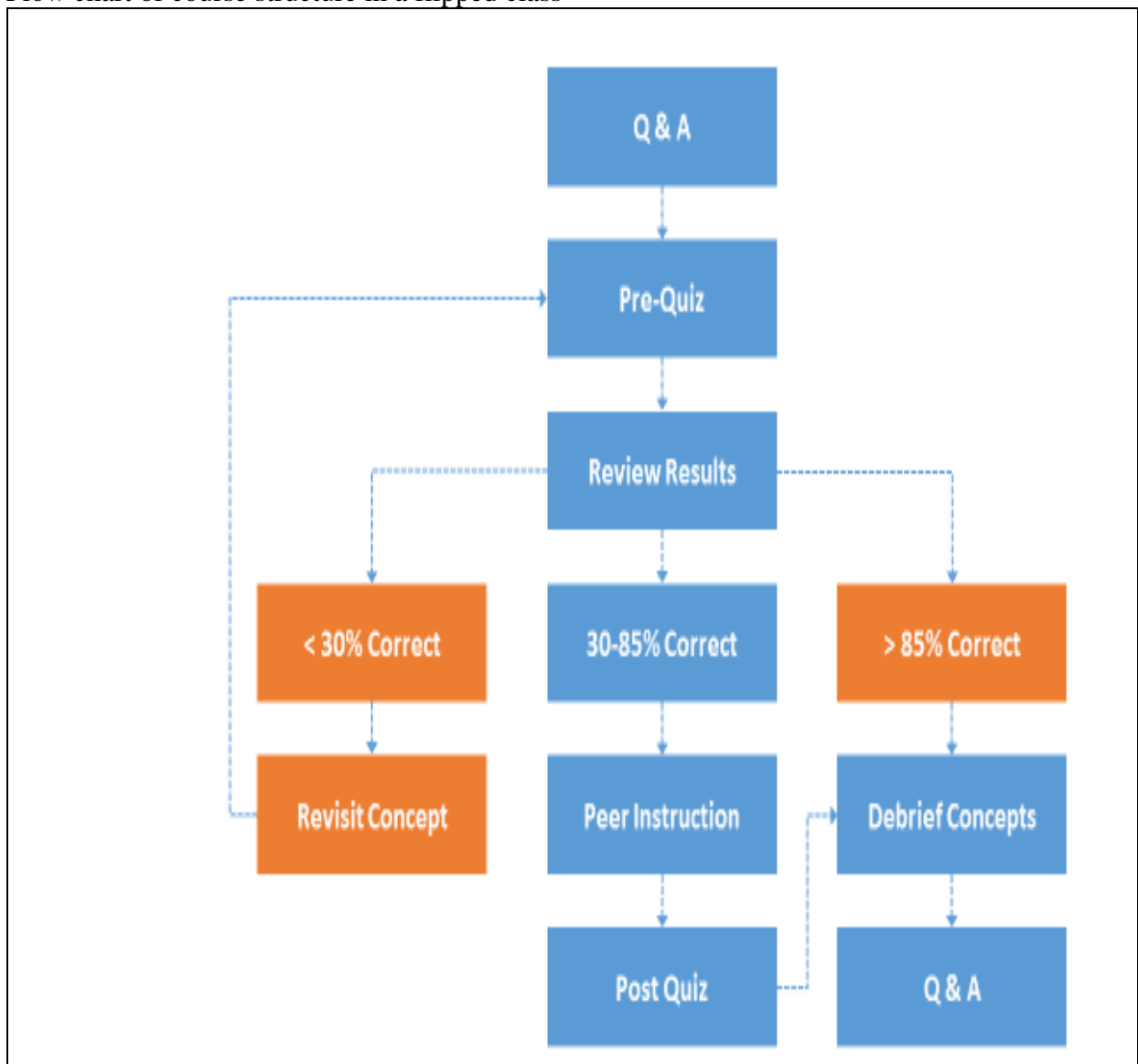
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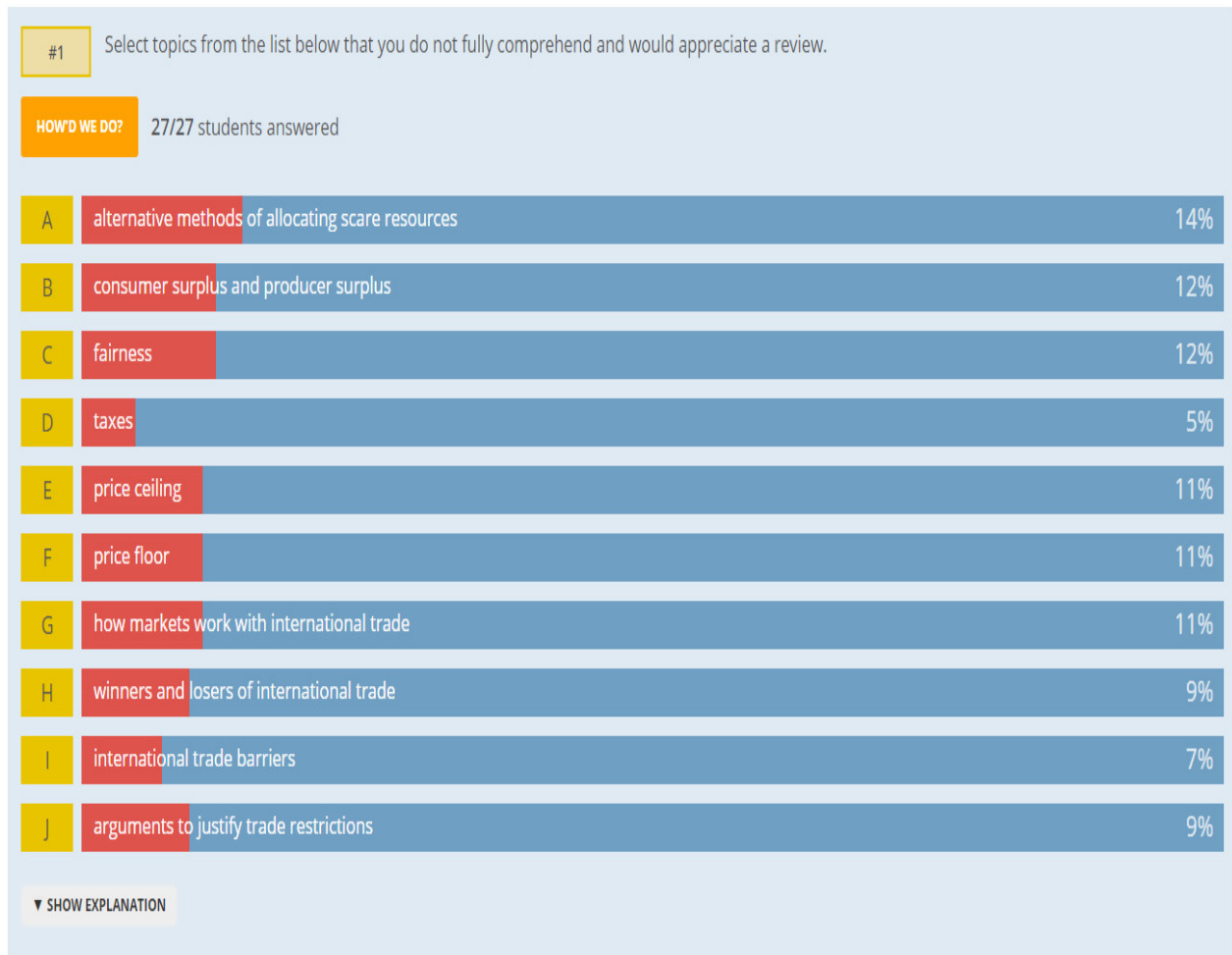
Table 1
Demographic Composition

Level of Study	Freshman	Sophomore	Junior	Senior
	43%	47%	8%	2%
Gender	**Male**	**Female**		
	54%	46%		
Age	**< 18**	**18 – 24**	**25 – 34**	
	26%	66%	8%	
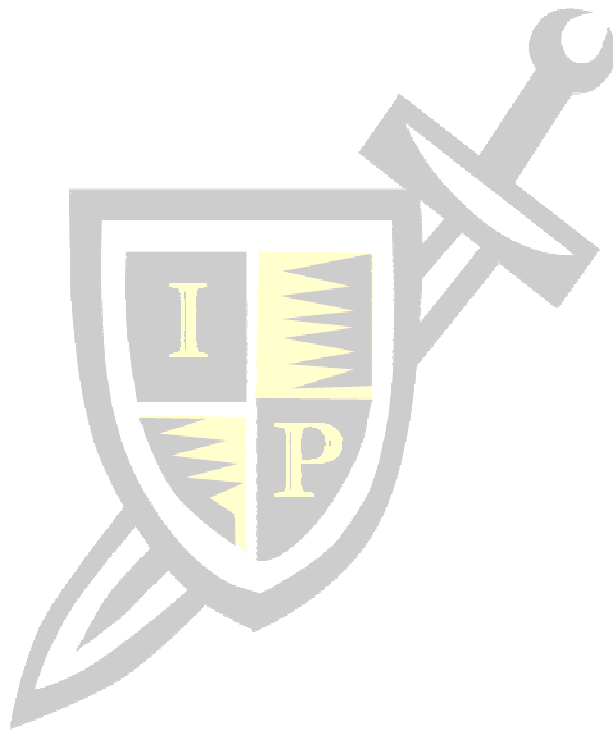
Figure 1

Flow chart of course structure in a flipped class

Figure 2

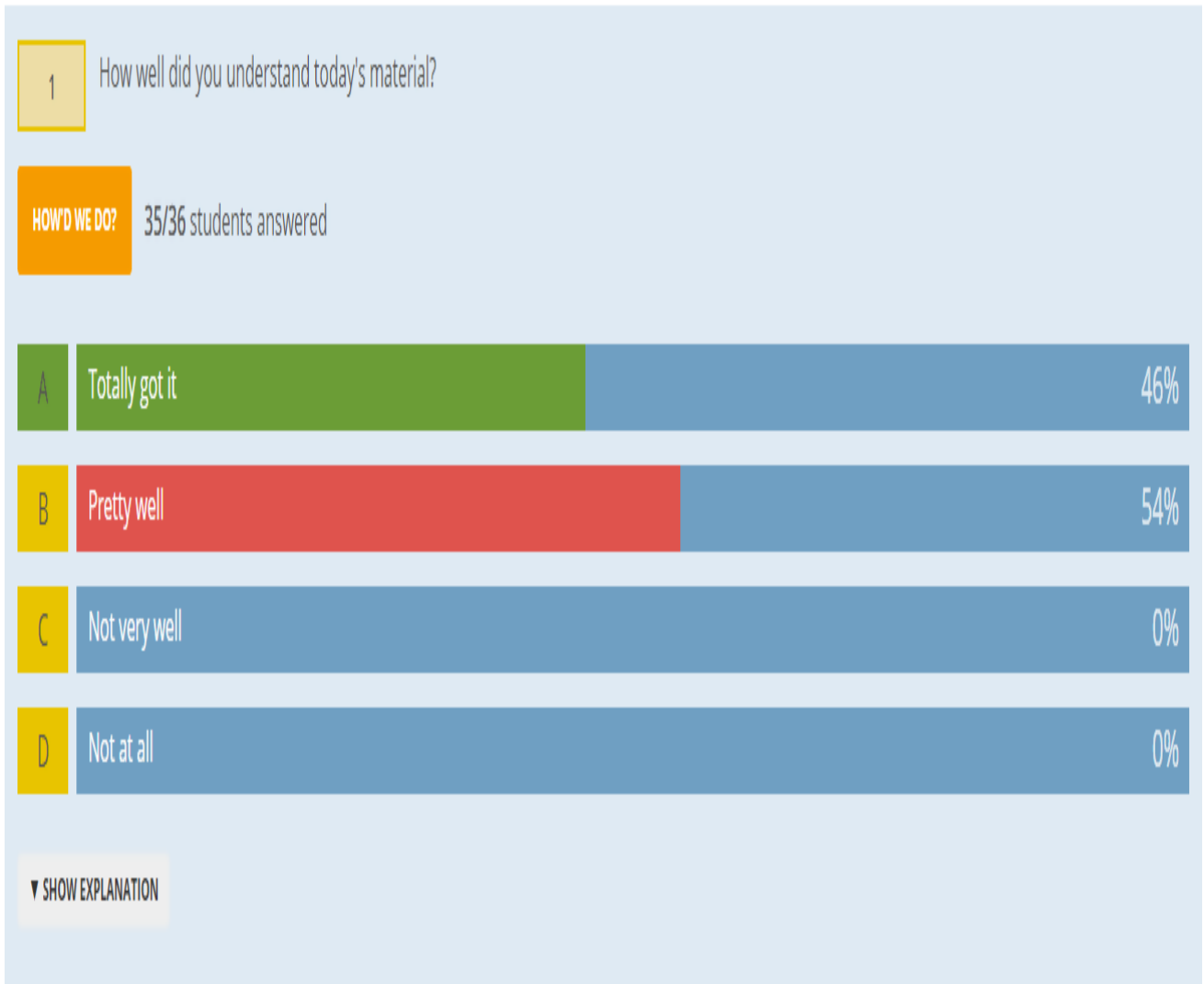Muddiest Point Quiz for Principles of Economics course

Table 2

The Classroom Critical Incident Questionnaire (CIQ)(Copied from Teaching Tips at
https://www.mona.uwi.edu/cetl/sites/default/files/cetl/teaching%20tips%20vol%205%20%23%2
06%20April.pdf)

Please take about five minutes to respond to the questions below about this weekend's class. Don't put
your name on the form - your responses are anonymous. If nothing comes to mind for any of the
questions just leave the space blank. At the next class we will share the group's responses with all of you.
Thanks for taking the time to do this. What you write will help us make the class more responsive to your
concerns.

1. At what moment in class this week did you feel most engaged with what was happening?

2. At what moment in class this week were you most distanced from what was happening?

3. What action that anyone (teacher or student) took this week did you find most affirming or
    helpful?

4. What action that anyone took this week did you find most puzzling or confusing?

5. What about the class this week surprised you the most? (This could be about your own reactions
    to what went on, something that someone did, or anything else that occurs).
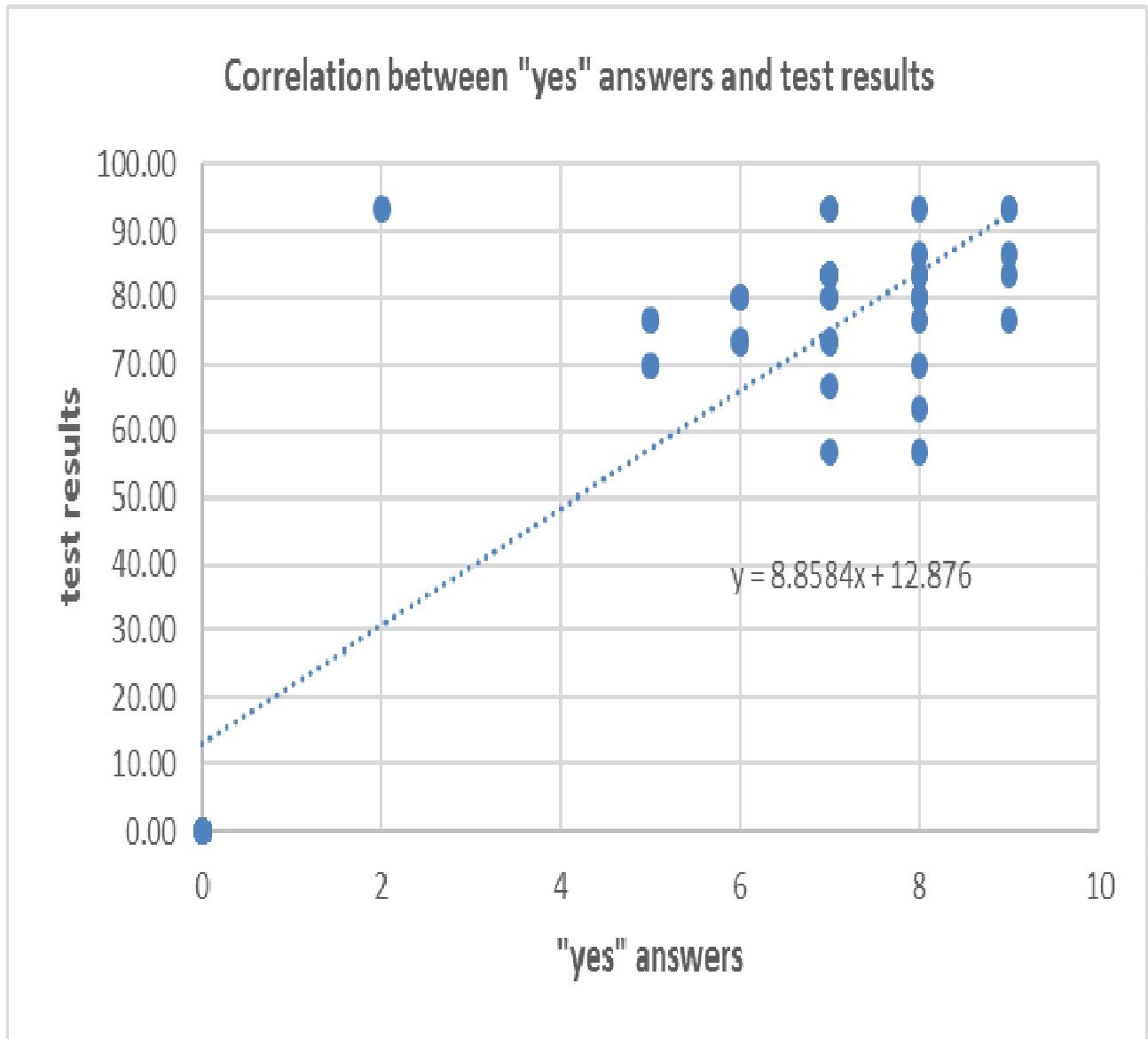
Figure 3

Exit Ticket

Figure 4

Test #2 results and "Yes" answers correlation (n = 35)

Correlation between "yes" answers and test results

$y = 8.8584x + 12.876$

test results

"yes" answers

Table 3

Student feedback from Exit Survey

#	Question	Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5
1	Reinforced important concepts					
2	Found Socrative easy					
3	Helped provide instant feedback					
4	Recommend Socrative					
5	Helped gauge understanding					
6	Improved performance in class					
7	Increased desire to come to class					
8	Increased willingness to ask questions					
9	Made class more enjoyable					
10	Increased interaction with peers					

Figure 5

CRS Survey Results
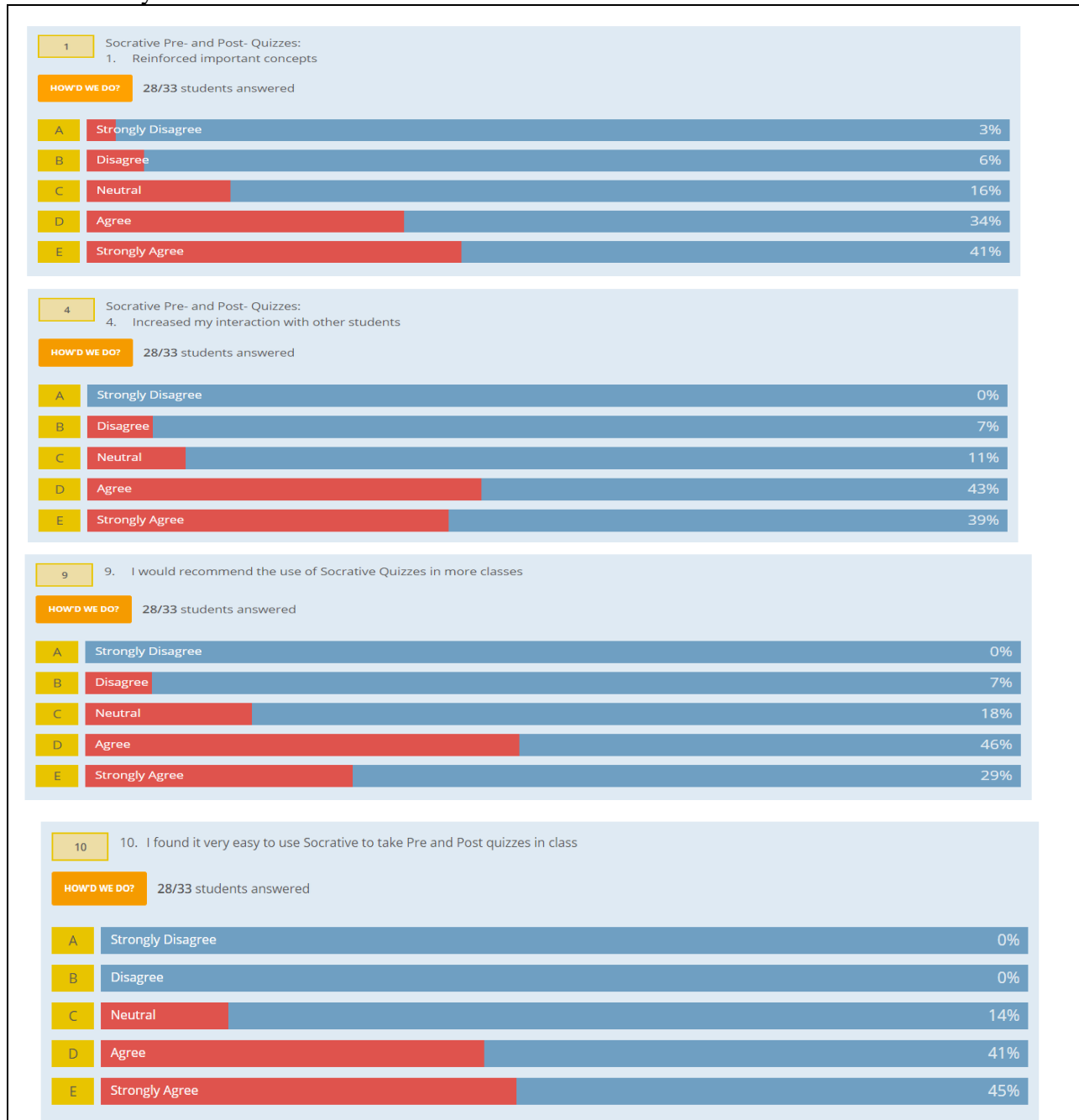
Table 4

Test Prep Checklist

Answer "Yes" only if you usually do the things described (as opposed to occasionally or never).

1. Do you read the Textbook chapter before class?
   a. Yes
   b. No

2. Do you listen to the Videos before class?
   a. Yes
   b. No

3. Do you review the PPT Slides before class?
   a. Yes
   b. No

4. Do you attempt to work through in-class problems/discussion questions in class with your classmates, practice using equations and make the effort to understand them while in class?
   a. Yes
   b. No

5. Do you participate actively in group discussions (contributing ideas, asking questions)?
   a. Yes
   b. No

6. Do you consult with the professor and ask for explanations as soon as possible when you are lost/need clarification?
   a. Yes
   b. No

7. Do you carefully go through the Study Guide/Mock Test (with classmates and quiz one another) before the test and convince yourself that you can do everything on it?
   a. Yes
   b. No

8. Do you attend the Review Session right before the test and ask questions about anything you aren't sure about?
   a. Yes
   b. No

9. Do you plan to get a reasonable night's sleep before the test and allocate a block of time to take it when your mind is alert and without distraction? (If your answer is no, your answers to 1- 8 may not matter.)
   a. Yes
   b. No

The more "Yes" responses you recorded, the better your preparation for the test. If you recorded two or more "No" responses, think seriously about making some changes in how you prepare for the NEXT test. Do whatever it takes to be able to answer YES to most of the questions.

Do you have any comments or questions for your professor?