

USING TURNINGPOINT[©] CLICKERS FOR ASSESSMENT AND CLASSROOM ENGAGEMENT

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1 Abstract

Critical inquiry, (information) literacy, and collaborative learning are strong themes in George Kuh's seminal work on high-impact practices. Using TurningPoint[©] technology, a clicker response system for the classroom, it is possible to create fast-paced, pedagogically-sound classroom activities that emphasize all three of these themes. TurningPoint[©] technology enhances student involvement and assessment; the focus will be the implementation of (graded) reading quizzes and (non-graded) challenges during a standard class period.

2 Assessment

2.1 Implementation into Curricular Design

Each course in a mathematics curriculum has its own style and content emphasis. Moreover, each faculty member has his/her own personality and strengths. Clickers' agility is particularly beneficial in this light, allowing different means of assessment in a variety of courses. Since clickers can be assigned (uniquely) to students and easily distributed, they are great for assessments.

1. Reading assignments: The most prevalent use of clicker assessment in the Franklin College mathematics curriculum is reading quizzes. These assessments are quick, flexible, and promote student engagement and preparation outside of class. They allow a shallow, simple grading of reading comprehension and

information literacy. When combined with note-taking and a question-asking period prior to the quiz, the reading quizzes promote critical inquiry and collaborative learning.

2. Online homework: Clickers are great supplements for online homework assessment. Since online homework is often done in groups and without direct instructor oversight, there is a need for effective, quick assessment of online homework concepts. In short, clickers provide a tech-savvy alternative to the homework quiz.
3. Written and Oral Assignments: Clickers have been used broadly in proof-based courses for two distinct purposes:
 - Evaluating written work: Providing anonymous feedback for evaluating proofs, giving the professor a chance to evaluate students' assessment of good proof-writing techniques and logical fallacies (this implementation is particularly useful in the Franklin College discrete mathematics curriculum); and
 - Evaluating oral presentations: This is similar in purpose for evaluating proof writing, but it lends itself to courses later in the curriculum. Students can provide feedback on both the the speaker himself/herself or be assessed on the topic being presented.
4. Team Projects: The desire to have team project experiences is ubiquitous in college mathematics curricula. However, assessing team projects is still difficult. The many variables involved – content, content delivery, audience comprehension, and team dynamics, just to name a few – make good, constructive assessment a chore. Ultimately, a faculty member needs a large set of coherent data to make sense of it all. Clickers are unique in their ability to do just that. Anonymous polls can be used where appropriate, and polls tied to student identification numbers can be used for different assessments.

2.2 Question Types

Within each assessment implementation, there can be different question templates used. For example, linear algebra tends to have more application question types whereas a liberal arts mathematics class may emphasize general involvement with the material. The following question types have been used successfully at Franklin College.

1. Conceptual: For example, do the linear algebra students understand what the properties and purpose of a basis set is?
2. Computational: For example, have the calculus II students practiced sufficiently to make a trigonometric substitution in an integral?

3. Reading Comprehension: Are students demonstrating the disposition necessary outside of class for success in their mathematics education?
4. Applications: Are students able to bring theory to practice and contribute to the solution of a real-world problem?
5. Connections: Can students change perspectives from one of these types listed above into another one? For example, in linear algebra, can a matrix be viewed as a system of equations to be solved (if possible), a representation of a graphical object, and a map/function to be composed with other maps?

3 Classroom Engagement

3.1 Modes of Daily Instruction

Professors vary widely in the method of content delivery. With a mathematics curriculum the delivery can vary among traditional lecture, an inverted classroom model, inquiry-based/discovery learning, discussions, and labs. Therefore a technology's agility is of vital importance. Does the technology adapt to different modes of instruction, and can it change to fit the needs of a class on a particular day? Clicker technology can meet those challenges. Here are some of the modes of instruction used at Franklin College that take advantage of clickers:

1. Introduction: A clicker quiz is a quick, easy way to begin a class. An introduction can be used in one of two distinct ways:
 - as an assessment tool for measuring students' preparation for class; or
 - as a jumping off point for the day's class.

And, of course, these purposes are not mutually exclusive.

Clickers excel in this application because they are easy to distribute (students can grab their own clicker – see the Assessment section) and the software boots quickly. In our experience, this is both a formative (in that it guides the upcoming class period) and summative (in that it grades students' preparation for class) assessment.

2. Transition: Both inquiry-based learning and inverted classroom models rely upon the students dictating the pace and content of class meetings, but it can be helpful to receive student feedback in any instructional model. Given the quick set-up and ability to pause during the activity/assessment, clickers provide ample opportunity for transition material; this is true even when the target for the transition is yet undetermined.

In the example included below (see the Examples section), students demonstrated that they were comfortable with the properties of exponential, logarithmic, and power functions with an exponent greater than 1. However, the clicker

assessment sparked a question regarding power functions with exponents less than 1. Thus the clickers were used mid-class to dictate the emphasis of the remainder of the class period. This is primarily a formative assessment.

3. Definition/Concept/Application: The interplay of syntax and semantics can be a hurdle in classrooms; students need to be fluent in the both the form and function of course content. Therefore, having a method of introducing, connecting, and/or assessing definitions, concepts, and applications is fruitful. Much like the Transition example above, an assessment that intermingles these three types of questions can highlight what portion of the material is still causing confusion. For example, it is often the definition (syntax), not the concept, that is the primary hurdle for students understanding isomorphisms. This can be a formative or summative assessment.
4. Wrap-Up: The book-end for the Introduction, the Wrap-Up focuses on measuring students' understanding of the day's course content and/or summarizing the key points. The flexibility and accessibility of clickers make them optimal for this use as well. This is primarily a summative assessment.

3.2 Pedagogical Outcomes

The pedagogical outcomes of using clickers are diverse and linked to the modes of instruction described above. They include

1. Diagnostics: The capability of clickers for “taking the pulse of a class” means they are great for diagnostic assessment of student learning. This can be used in two different ways:
 - for the current class period, as in most of the methods listed above (in particular, the transition technique was used for exactly this purpose); or
 - for designing class-to-class transitions, which can be assessed effectively using the wrap-up/introduction techniques.
2. Facilitation of targeted instruction: Clickers allow the production, assessment, and display of targeted problems. This is typical of most textbooks, but the ability for immediate feedback makes them attractive for targeted instruction.
3. Dispositional encouragement: If the mode of instruction employed requires a heightened level of student engagement (e.g., an inverted classroom or inquiry-based learning model), clickers are fantastic options for encouraging student participation and preparedness. Clickers make natural tools for introductory and wrap-up assessments (see above). And not only do the assessments themselves promote student involvement, they measure student participation throughout and/or before the class period.

4. Motivation: Since so many students, particularly math majors, are competitive by nature, clickers create a “game show” atmosphere that can be leveraged. Students demonstrate a desire to perform well – better than their colleagues. This healthy competition promotes a culture of preparedness and classroom engagement.

4 Examples

These examples of in-class assessments and activities were referenced previously in this article.

Transition Example: <https://tinyurl.com/mwvgnle>

Definition/Construction/Application Example: <https://tinyurl.com/l68uvvw>

Wrap-Up Example: <https://tinyurl.com/lahbc8g>

5 Conclusion

A set of Turning Point[©] clickers is very affordable. As of the autumn of 2016, a single clicker costs \$50; however, clickers only need to be unique per student per class for assessment, and there is no need to have a separate set for every class. Therefore, purchasing a set of clickers is an affordable investment for day-to-day assessment and engagement across the curriculum.

Assessments that, in our experience, work well include reading assignments, supplements to online homework, analysis of written and oral presentations, and the evaluation of team projects. These assessments can take the form of conceptual, computational, comprehension, application, or connection-based questions. Clickers also promote classroom engagement by being useful tools in introductions, transitions, applications, and wrap-ups. This diverse set of uses yields several pedagogical benefits: diagnosing misunderstanding (and understanding) of material, motivation of constructive learning behaviors and dispositions, and targeted instruction.