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Using Clickers to Collect Formative Feedback on Teaching: A Tool for Faculty Development

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Abstract

Incorporation of clicker technology in an introductory chemistry class is described as a method for collecting and automatically tabulating student feedback for use in formative faculty development. Students are polled in real-time on issues of classroom management and the success of various teaching methods. Tabulated data is displayed on the classroom screen and used to facilitate classroom discussion. This method was introduced in a first-year general chemistry class for non-majors and resulted in unusually high student evaluation marks in categories related to communication with the instructor. The success of the method was evaluated using mid-semester and final student evaluations, informal written student evaluations, peer observation, and instructor reflection.

Keywords

Formative feedback, faculty development, clickers, audience response devices

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Introduction

Student response devices, commonly called “clickers,” have been widely used to enhance student participation in classes and to deliver real-time feedback to students showing their progress. Continual feedback increases student engagement with the material and promotes an active learning environment (Boatright-Horowitz, 2009; Bunce, Flens, Neiles, 2010; Gauci, Dantas, Williams, Kemm, 2009; Kenwright 2009; Terrion, Aceti, 2012). Clickers have also been used to provide feedback to the instructor with good results in “just in time” teaching. In this approach, carefully crafted questions are sprinkled throughout the lecture to allow the instructor to get real time assessment of students’ learning and to provide opportunities to correct mistakes or misunderstandings in a timely manner (Deleo, Eichenholtz, & Sosin, 2009; King, 2011; MacArthur & Jones, 2008; Prather & Brissenden 2009). These assessment methods focus on the instructor’s interpretation of the student’s learning and mainly provide formative feedback to the student.

Clickers can also provide an opportunity to collect formative feedback for faculty. This can be a particularly useful tool for new teachers. The technique presented here turns the tables on previous clicker methods and asks students for direct feedback on teaching and learning, providing real-time formative assessment for the faculty member. Students respond to a multiple choice question regarding an aspect of class policy or their classroom experience. The clicker software tabulates the results and - if the instructor chooses - displays them at the front of the class. The instructor can then use this feedback to initiate classroom discussion that may lead to specific suggestions for improvement for both student and teacher.

Formative feedback from students is highly effective in developing teaching skills and can initiate fundamental shifts in instructor perspectives on teaching and learning (Sadler, 2012; Pickering, 2006). Such feedback has been collected in a wide variety of ways, including: student observations taken during each class period (Miles, 1989), minute papers (Angelo & Cross, 1993), peer observation (Martin & Double, 1998) and facilitated student focus groups (Clark & Redmond, 1982), among others.

Mid-semester evaluations are another common strategy (Lewis, 2001a).

All of these feedback methods produce data that is deeply informative, but it can be quite time consuming to fully process and tabulate the results. For this reason, collection of feedback is often reserved for high priority, red-flag issues rather than day-to-day conversations with students about the mechanics of teaching and learning. Open-ended survey questions in particular can produce an overwhelming variety of student answers, which require additional steps to interpret (Lewis, 2001b). Doubt about the universality of a particular student's perspective often creates an obstacle for the well-intentioned faculty member seeking to use student feedback. This doubt can lead instructors to delay change until they have gathered more results, or to doubt the efficacy of changes that they have made.

Clickers can be invaluable tools for assessing the generality of student sentiment in the classroom. Clickers excel at polling large groups in real time about specific questions of interest to the instructor. The device technology records and tabulates results automatically, greatly facilitating the process of collecting and interpreting feedback results. Responses can be tracked or fully anonymous (to both students and instructor), thus reducing the social pressures present in any faculty-student dialogue. Appropriately phrased questions can provide useful feedback to the instructor and allow students to see where their classmates stand on a particular issue, if the instructor chooses to share the results. Showing students the polling data is particularly useful in cases where an instructor is balancing the needs of multiple constituencies (bimodal distributions, different academic backgrounds, etc.).

As it takes less than a minute to poll and just a few minutes to discuss student responses, asking questions in a clicker-implemented classroom is quick and can provide immediate and transparent feedback both to the instructor and to the students. Further dialogue offers the faculty member an opportunity to respond to the feedback and to discuss possible solutions or next steps, and allows students to voice specific challenges, problems, or concerns. Open discussion of topics related to students' experience of the class can be helpful in

building rapport between student and instructor, which has been found to increase student motivation and engagement in the classroom (Benson, Cohen, Buskist, 2005), and may also improve instructor evaluation marks (Delucchi, 2000). Finally, sharing compiled data with the students allows them to gauge how broadly their criticisms are held among their peers, thus calibrating their expectations for an appropriate response.

In this project, clickers were used in a one-semester general chemistry class taught by a first-year professor in the undergraduate college of a small, master's level institution. In addition to polling for content knowledge and student engagement, clicker polling was found to be a useful tool for establishing faculty-student conversation in a large lecture format. The local institutional review board reviewed and approved publication of this study.

Background of the class/demographics

Clickers were introduced primarily as a method of maintaining student engagement in two sections (56 and 64 students) of a lecture class in introductory chemistry. This class is one of the largest lecture classes on a campus where students are accustomed to a high degree of faculty contact and attention.

No demographic information was collected as a part of this study, but the class composition reflects the general campus population. All students on the campus are female, and one-fifth identify themselves as African American, Latina, Asian, Native American or multi-racial. Many are also first-generation college students. Students come from up to 40 states and 39 countries. Most students in the class were traditional-aged undergraduates between the ages of 18 and 20. There were a small number of international students and returning or part time students above the age of 25 in the class, as well as one or two graduate students fulfilling program prerequisites.

The students are primarily first-year students from nutrition, physical therapy, and other allied health majors for whom chemistry is a prerequisite but not a strong interest. A majority of the students have had some chemistry in high school, though many did poorly in previous courses and therefore entered the class with a fair amount of trepidation. A

smaller but significant number of students have had no previous exposure to the material. Most students are required to maintain a B average or above in order to continue in their program of study, leading to increased awareness of grades.

Graded assessments in the class consisted of 3 one-hour exams, 8 quizzes of ten minutes each (the two lowest grades were dropped), 10 laboratory sessions, and a final exam. In addition to these traditional assessments, students answered daily clicker questions to assess their understanding of material covered in lecture and in the homework. These clicker questions totaled 50 out of 1000 possible points for the semester. Students were awarded 80% of the possible points for attempting an answer, and full credit for giving the correct answer. An additional 25 points of extra credit were awarded based on 3 in-class clicker competitions held throughout the semester during class time, each of which consisted of at least 30 questions of varying difficulty administered in a group format. Students were told that no points would be awarded for answering feedback questions, so there was no grade pressure to comply.

Method

Clickers were used in all lecture periods, so it was simple to insert informal, specific questions asking students about their experience of the class. Over time, these questions became an integral part of the student-instructor dialogue in the course. Students were polled using the clickers, and their responses were displayed in real-time on the projector screen. The instructor then used this feedback to initiate classroom discussion about these topics. In the case of a possibly contentious topic or one that students might be uncomfortable raising on their own (e.g. rating the pace or importance of lecture), use of clickers provided an additional layer of anonymity to students. After seeing the tabulated results, the instructor pointed out that there were several students in the room that identified with a particular survey response, and then asked specific questions about what might be most helpful to those students in the future, soliciting responses from all students in the class. In this way, students who responded openly were not necessarily identified as those who had

complained, reducing peer pressure as well as the tendency to be intimidated by the instructor.

Examples of feedback solicited in this manner included:

- Did you find the first quiz/exam to be easier, harder, or about the same level of difficulty as you expected it to be?
- Did the practice exam give you an accurate idea of the length, types of questions, and difficulty of the exam? (yes, no, didn't use).
- Is the pace of lecture: too fast to follow, too slow to be interesting, or a good pace for reviewing the previous night's readings?
- How important is the lecture format in helping you understand the readings? (very important, somewhat important, neutral, not too important, not important at all).
- Which of the following best describes your needs for external help from the center for academic achievement? (have a tutor, need to get a tutor, signed up but on wait list, don't need a tutor).
- How helpful was it to have clicker questions integrated into the past couple of lectures? (very helpful – please do again, somewhat helpful – do occasionally, neutral – doesn't matter, somewhat unhelpful – don't do often, very unhelpful – don't do at all)

“Pace of lecture” stood out among this list as a possible area for improvement, and so was designated by the instructor as a focal point for ongoing professional development efforts throughout the rest of the semester. Several metrics were used to assess progress toward the faculty development goals developed as a result of student polling:

- The instructor asked individual students for their opinions informally in office hours and outside of class, specifically

addressing issues that had been previously identified by clicker polling in class.

- Students were re-pollled about the pace of lecture later in the semester to assess progress and continue discussion (Table 1). The first poll was conducted in week 5 and the second poll in week 10. Results for the two course sections were not significantly different according to a difference in means t-test ($p < .10$, two-tailed test). Only one question (helpful review of readings) has a p value greater than 0.05. Combined results are reported in Table 1.
- Formal, anonymous class evaluations were taken in week 6 (mid-semester) after exam 1, and in the second-to-last class of the semester (final evaluations, week 14) to collect student opinions on teaching in the course as a whole. Evaluations included a standardized form with questions about instructor engagement and student learning, as well as open-ended questions about student learning in the course.
- The instructor solicited peer feedback from senior faculty members tenured in the Chemistry and Philosophy departments. These senior faculty members completed one classroom observation each, in week 7 and week 11, and provided experienced faculty perspectives on the issues raised by students during clicker polling. Peer feedback included a classroom ethnography, where the visiting professor observed student and instructor interactions as a neutral third party. Observers also completed a checklist of items and indicated specific examples that demonstrated good classroom practices and student engagement. Items included clear communication of purpose by instructor, use of concrete examples, fostering student-to-student interaction and active learning, perceived student comfort in asking questions and active student participation in classroom discussion.
- The instructor collected personal reflections on class dynamics, successes and failures on a weekly basis

throughout the course. Feedback from both faculty and students was integrated into an ongoing plan of improvement.

Results and Discussion

The results of these different metrics produced a broad overview of the possible areas for improvement in classroom teaching throughout the semester. Balancing formal and informal metrics of student and faculty perspectives provided a way to calibrate new faculty expectations both to the desires of students and to the expectations of the college.

Student response:

Students were given a one-page written form on the last day of class and were asked to provide anonymous feedback - to be used by the instructor only - about the course. Forty-four students responded, compared to the 106 that responded to the formal final evaluation. Survey responses are summarized in Table 2 for questions that specifically address the effect of clickers on student comfort level in the class. Of the students who responded to the survey, most reported that they enjoyed using the clickers and rated them highly across the board. As shown in Table 2, a majority of students indicated that they also found the clickers to be helpful in communicating with the professor, though given the smaller number of respondents there may be selection bias in these results.

Faculty Peer Observation:

Both peer observers noted without prior preparation that students seemed comfortable asking questions and communicating with the instructor. Neither observer happened to be present on a day when clicker questions were used to solicit instructor-specific feedback, but both observed other clicker modalities and noted student interest and engagement with the course material. Both observers were asked to comment on pace and structure of lecture to provide an outside perspective on the student feedback presented in Table 1.

Neither observer felt that the pace of lecture was too fast, and the second suggested that it should even be increased. Both peer evaluators found the lecture to be well organized and presented clearly, though the second observer noted that repetitive student questions sometimes interrupted the flow of presentation.

Summative Student Evaluations:

Mid-semester student evaluation questions that address clarity and organization of the course are shown in Figure 1. These categories showed lower scores than other metrics, perhaps reflecting the student sense that the pace of lecture was too fast. Overall teaching was considered satisfactory or better by most students, though there is clearly still room for improvement. By contrast, the two standard questions referring to instructor openness and ability of students to ask questions received much higher evaluations. This ranking is very unusual in a course of this type and likely reflects student appreciation of the continuing conversations around course policy that were facilitated via clicker.

Final evaluation results were similar to the mid-semester student evaluations, though the averages were somewhat lower. The mean rating dropped between 0.23 and 0.33 points on a 5-point scale for the questions shown. This difference was statistically significant according to a two-tailed difference of means t-test ($p < 0.05$ for all questions except the first regarding clarity, where $p < 0.10$).

This drop in student satisfaction could be attributed to end-of-semester ennui, an unpopular change in quiz administration policies in response to reported instances of cheating, or to student perception of a change in instructor engagement. Written responses by students were included as a part of the overall evaluation, and indicated that several students continued to find the pace of lecture to be too fast, and that they continued to struggle with concepts that required mathematical reasoning.

Table 1. Student responses to questions regarding pace of lecture

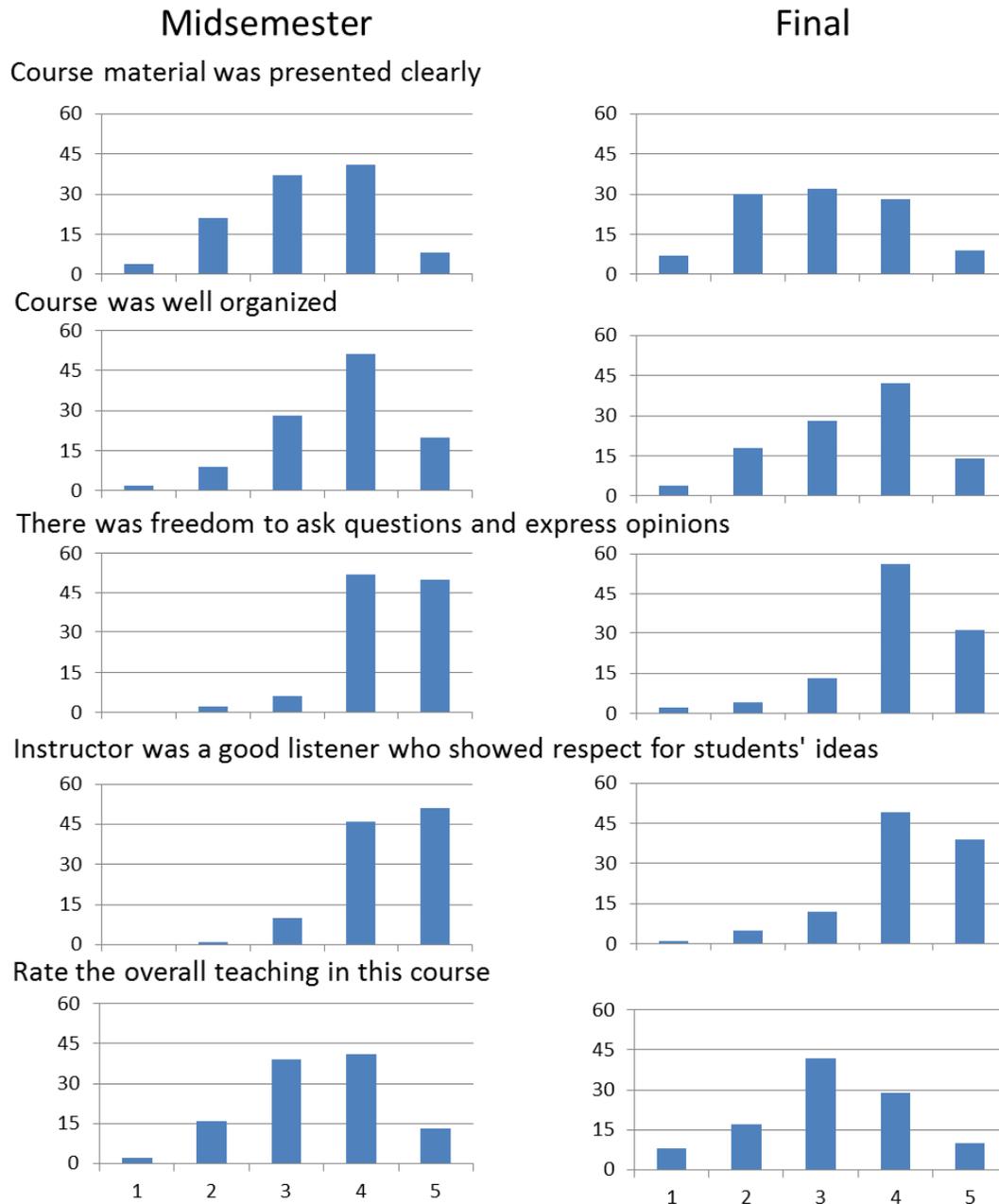
(Week 5) Do you find lecture to be:	Number of students responding
Too fast to follow	35
Too slow or repetitive of topics covered in the book	7
A helpful review of readings	58
Total	101
(Week 10) Please rate the pace of lecture over the past couple of weeks:	
Much better/just fine	24
Somewhat better, still too fast	35
Hasn't changed	31
Somewhat worse	7
Much worse	1
Total	98

Table 2. Student Perspectives on the Effectiveness of Clickers

Clickers:	St. disagree	Disagree	Neutral	Agree	St. agree	Total respondents
Helped me communicate with the professor	0	2	12	23	7	44
Made me more comfortable asking questions	0	1	13	19	12	45
Helped me compare myself to my peers	0	1	3	25	14	33

The mean evaluation scores for questions 3 and 4 regarding instructor openness (ask questions, respect ideas) reported in Figure 1 were significantly higher than the results for questions 1 and 2 regarding teaching quality (clarity, organization). This was true for both midterm and final evaluations ($p < 0.01$, two-tailed), indicating strong rapport between students and instructor.

Figure 1. Summary of feedback from student evaluations.



All results are plotted on a scale from 1-5, where 1 is "strongly disagree" and 5 is "strongly agree." Results for the midterm evaluation are shown in the left column and final evaluation scores on the right. There were no statistically significant differences between course sections, so counts were combined for simplicity.

Instructor Reflection:

Overall, clickers were very useful in establishing and maintaining a dialogue with students. Specific instances where student feedback was useful in helping to fine-tune course instruction are given below.

In the case of exam/quiz difficulty, greater than 80% of students indicated that the graded assessment was of the expected difficulty, and that the practice exam had been a fair representation of the problems asked. This kind of response cut down on grumbling from a few very vocal students, and gave the class an opportunity to discuss places where they were caught off guard.

Midway through the semester, the instructor was considering changing the class structure dramatically to include a more active classroom built around clicker questions and less lecture time. Students were polled about the importance of the lecture format in supporting their understanding and 70% of students indicated that lecture was either very important or somewhat important in building their understanding of the material. After discussing the options, the instructor and students agreed that a more moderate rearrangement would be best.

Students were polled again a few weeks later, after integrating clicker questions more directly into the class material. At that point, 75% of the class indicated that the integrated questions had been very helpful or somewhat helpful, and suggested that the practice be continued. The clicker questions took extra time to prepare and administer, and had caused some minor classroom management difficulties with switching back and forth between board work and presentation modes. Positive student feedback played a significant role in the instructor's decision to keep the integrated clicker questions. Based on the success of the clicker integration, they will be fully incorporated into all lectures next time that this course is offered.

Pace of lecture was a continuing struggle throughout the semester. The student population for this class tends to be bimodal, as some students are seeing the material for the first time and for others it is simply a review. Math preparation and

problem solving skills are also widely varied within the student body, making it difficult to balance differing student needs. Discussing clicker results gave the instructor an opportunity to explain those difficulties to the students, and allowed the class to brainstorm possible solutions to these tricky issues.

In the end, making significant adjustments to the lecture pace and style did not make a significant difference in the student perception that lecture was too fast (Table 1), although the majority of students were aware that the pace had changed. This result likely reflects the many factors at play in student's overall assessment of the pace of lecture. For example, the instructor increased the amount of class time spent on each problem and gave detailed explanations for each step, but this might not have been sufficient to improve students' absorption of the course material in the absence of appropriate mathematical reasoning skills. Many students also reported feeling generally overwhelmed by the pace of college courses in general; the survey results in Table 1 may reflect this difficulty as well.

Balancing student feedback with faculty opinions was critical in judging an appropriate adjustment to the pace of lecture. Both faculty observers felt that the pace and structure of lecture was fine after the initial decrease at the beginning of the semester. They also agreed with the instructor's self-assessment that further decrease in the pace of lecture might begin to compromise coverage of the required material. The initial decrease in pace was warranted, given the students' difficulty with mathematical manipulations, but further decrease would have reduced the rigor and completeness of the course. In the future, the instructor plans to focus more on helping students attain the study and note taking skills to keep up with the faster pace, rather than simply slowing down the material coverage.

After the second polling, the instructor facilitated a class discussion about what specific issues were causing students difficulty in keeping up with lecture and suggested several approaches that students could take to address them. The changes that had already been made were highlighted, and the students made specific suggestions for other changes that they felt would be helpful.

It would have been difficult to facilitate the continual collection of student feedback described above in a large lecture format without clickers. The administrative burden of passing out, collecting, and sorting paper forms would have decreased the number of polls that could be administered, and the instructor would not have had time to tabulate the data for class discussion. These brief classroom discussions were essential to getting at the heart of the problems that students were experiencing, and to correctly interpreting their course ratings. The instructor had expected some polling fatigue over the course of the semester, but students always seemed happy to voice their opinions on topics of class management and to have helpful discussions about what to do next.

In general, students seemed to feel more comfortable having an honest discussion after they (and the instructor) had seen the range of responses in the class. From anecdotal observation, students appreciated the opportunity to “speak up” about class issues without having to be the only one raising their hand. With rapid and continuous feedback, it was possible to assess many more modes of teaching than could otherwise have been evaluated in a single semester. The instructor was able to make smaller, more frequent adjustments to promote student learning based on clicker feedback.

As with any feedback, it is essential to ask only questions for which one is prepared to hear an honest answer, and to ask them in a way that does not lead to class policy devolving into a popular vote. When polling students about whether the exam was harder, easier, or the same as students expected, the questions emphasized the *as expected* rather than asking whether it was harder or easier than it should be. Questions about the pace of lecture were framed in the context of striking a balance between covering the material thoroughly enough that students would be prepared for the exam (and their future classes) and covering it slowly enough that everyone could keep up.

One student did argue vehemently with the instructor after class about a policy that she didn’t like, and felt that the instructor should poll everyone to see what the class wanted when her suggestion was refused (this poll was not

administered). This is likely a result of a perceived “democracy” due to the clicker polling, and must be handled with care to avoid giving students too much control over class policy.

Wording is also critical to ensuring clear polling results. In the future, the question about pace of lecture will be changed to: “In general, I: 1) Have trouble keeping up with lecture 2) Am able to understand most of what is covered in lecture 3) Am not able to understand material covered in lecture.” This subtle rephrasing will help to emphasize that understanding is a collaborative process and will open the way for discussions of student preparedness, note taking, and study skills. This places some of the responsibility for learning on the student, rather than suggesting that pace of lecture is the only criterion that determines understanding.

Splitting the follow-up poll shown in Table 1 into two separate questions would also be beneficial. As written, it conflates students’ opinions of the current pace of lecture with perceived improvement since the last poll. Separating these two ratings would help to facilitate interpretation of the results.

It was essential that the instructor ask questions only when fully prepared for public criticism and ready to respond openly on a topic. Clicker polling is a very public way of giving voice to disgruntled students, and a desire to engage and discuss is critically important to the success of this method. If the instructor is prepared for criticism, then clicker polling can be used to foster open discussion by allowing the instructor to both hear and respond to student complaints, but public polling should always be used with appropriate caution.

The clicker method is an ideal way of getting information about the generality of a complaint (or praise!) that has been expressed by a few students and that the instructor suspects may be more widely held. It is also useful for gauging the success of a particular technique or strategy in the moment, rather than waiting for the end of semester to get more cumulative classroom results. Clicker polling can help with interpretation of class mood and other intangibles in the classroom; it is ideal for that moment where the instructor is sure that there’s something going on but isn’t really sure what it is.

Finally, clicker polling was helpful in encouraging students to come forward and discuss potentially sensitive matters that they might otherwise be afraid to bring up. It reassured weak students that they were not alone in feeling confused, and emboldened all students to ask for help. Positive and constructive responses to student feedback also demonstrated to students that their instructor really did want to hear from them.

Conclusions:

Overall, the instructor found the process of repeatedly surveying and discussing results with students to be very useful, and students indicated that it was helpful as well. Faculty colleagues noted that students were very comfortable asking questions and expressing opinions in the classroom. Clicker-implemented, instructor-led formative feedback can greatly speed up the process of faculty development by providing a low-risk opportunity to measure the success of teaching techniques in real time. The ease of administering and collecting data allows frequent contact with students who might not otherwise come forward. The ability to display poll results in real-time for classroom discussion is an important advantage of this method. Seeing the majority vote helped some students to speak up and others to realize that they needed to adjust their own expectations, both of which are useful outcomes. The clicker feedback also helped to confirm or correct instructor assessments of the classroom, and served as a useful test for day-to-day practices. Comparison with other faculty perspectives was an essential part of balancing student polling results with existing college standards. This is important in any situation where the student ideal might not reflect the practical needs of the classroom.

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