



# TECHNICAL REPORT

## How iClicker Reef implementation decisions relate to student outcomes

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Technical Report with iClicker Reef, 2018-01

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In order to provide instructors and other faculty the most useful, practical, and actionable evidence of whether a digital learning tool will work for students in their educational environments, evaluation of product effectiveness should begin in development and continue once a product is on the market. By defining implementation use cases and examining how implementation decisions relate to student outcomes, instructors have valuable insights to refer to when using iClicker Reef in the classroom. This paper presents the results from the iClicker Reef implementation study and includes a discussion about how identifying and defining use cases can help instructors make research-driven decisions about how to use a digital learning tool.

## Background

Particularly in large college classrooms, instructors have used student response systems to encourage students to engage more in their learning. Results from both instructors and students have indicated that student response systems are beneficial in the classroom (Dangel & Wang, 2008). In a study conducted at the University of Wisconsin, faculty reported that the benefits of using student response systems are higher levels of interaction, participation, and engagement among students resulting in more student discussions. Faculty members also said that, when using student response systems, they better understand the knowledge and skills their students attain and there is increased overall performance throughout the class. Students also agreed that using a student response system in the classroom leads to higher levels of student engagement, participation, and attentiveness throughout class. Overall, students liked the instant feedback the student response systems provide and believed that using student response systems is beneficial to their learning (Kaleta & Joosten, 2007). It has been demonstrated that student response systems improve student engagement and provide quick feedback, encouraging student learning and good teaching methods when being used (Dangel & Wang, 2008).

## iClicker Reef

In 1997, a team of physicists at the University of Illinois (Tim Stelzer, Mats Selen, Gary Gladding, and Benny Brown) developed their own wireless radio frequency system as part of the university's overall effort to make large introductory classes more engaging. With its simple, reliable technology and focus on pedagogical content, iClicker made it possible for instructors to take attendance, engage students in even the largest classrooms and lecture halls, and use the students' responses to decide

which topics to emphasize.

Macmillan acquired iClicker in 2005, making significant investments in its hardware and software. In 2014, the iClicker team introduced Reef Education (now called iClicker Cloud), a mobile-optimized, cloud-based classroom engagement solution that gave instructors a choice between a clicker-based infrared system and one students could access through a computer, smartphone, or tablet.

Thus far, numerous iClicker Reef case studies have been conducted. The case studies have covered a range of content areas and have been conducted at different universities. The case studies have included an overview of the course(s), motivation for using iClicker, implementation and use, results, and conclusions. Many learning outcomes have been associated with the case studies (e.g. attendance and punctuality, subject matter understanding and learning, class participation and interactivity, student interest, teacher feedback, etc.). The results of these studies have been descriptive in nature.

Products developed by Macmillan Learning have followed a research, design, and evaluation lifecycle. At each stage of this lifecycle, evidence is collected, and as a product matures, the claims made based on that evidence become more rigorous. Given that all studies of iClicker Reef have been descriptive thus far, the goal of this study is focused on advancing the research portfolio that supports iClicker Reef by providing a correlational study. A quasi-experimental study has been underway and will be released in fall 2018.

## Implementation Study

We invited instructors from various educational contexts to use iClicker Reef for a complete semester. The mode (whether students used remotes or mobile devices) was the instructor's choice. During these implementation studies, we documented implementation and collected systematic data on the user experience and student and instructor outcomes. We learned what product effects can be observed in specific settings with deeply understood contexts and evaluated whether identified use cases relate to learning outcomes. The study design and methodology have been outlined below, as well as the findings and implications.

**Research questions.** Five research questions were explored in the implementation study.

1. How is iClicker Reef being used within and across educational environments? What are the motivations for use cases? Is there a difference in use by type of mobile device?
2. How is use of iClicker Reef related to student learning, student engagement, and student satisfaction with the course? Is there variability across different use cases?
3. What iClicker Reef question types are being asked in class, and what is the variability in learning performance based on question types?
4. Is use of iClicker Reef to facilitate class interaction (i.e. asking opinions, soliciting feedback) associated with a different relationship to student performance as compared to using iClicker Reef for formative assessment (i.e. actually testing students' knowledge)?
5. What are instructor and student perceptions of iClicker Reef?

**Sample.** Current iClicker Reef users were recruited for this study so that implementation practices were already defined by the instructors. Instructors were recruited to participate based on the course discipline, size and geographic location of the institution, type of iClicker device used (i.e. remotes, mobile devices), average class size, instructor teaching experience, and student demographics. The goal was to provide diversity across these variables. The students who attended the instructors' courses were offered use of the product free of charge during the study period.

**Institution and instructor sample.** In total, six instructors from five public institutions were recruited to participate. Two of the instructors taught at a moderate-sized four-year institution in the Midwest, one instructor taught at a large four-year institution in the Midwest, one instructor taught at a moderate-sized two-year institution in the West, one instructor taught at a large four-year institution in the Southeast, and one instructor taught at a large four-year institution in Northeast Canada. One instructor in the sample (17%) had been teaching for more than 15 years, four (67%) had been teaching between six and 15 years, and one (17%) had been teaching for under five years. There was variation regarding how comfortable the instructors felt using technology (responses ranged from "very uncomfortable" to "very comfortable") at the beginning of the semester. The majority of the instructors indicated that they planned to use iClicker's polling features and believed that their students primarily valued the interactivity iClicker provides.

**Student sample.** Participation in the study and its data collection activities were completely voluntary. Students could opt to participate in the overall study and still opt out of any data collection activity. Of the 2,142 students registered in the study courses, 731 (34%) consented to participate in the implementation study. Of the 731 students who consented to participate, 645 students opted to complete the baseline survey and 371 students opted to complete the end-of-term survey.

Since data from students who opted not to participate in the study were unavailable, it was not possible to analyze differences between students who decided to participate as compared to those who chose not to participate. Data from the 86 students who opted to participate in the study but chose not to complete either survey were also unavailable. However, five variables were used to compare students who opted to complete the baseline survey (referenced as noncompleters) to those who completed the end-of-term survey (referenced as completers). The five variables for comparison were as follows: what is your comfort level using digital tools in the classroom, how strongly do you agree that digital tools can enhance your learning in the classroom, how many hours per week do you expect to spend studying or doing homework outside the classroom, how often do you predict you will attend class this semester, and which of the following statements reflects how you feel about attending class. The noncompleters' and completers' responses were statistically similar for the first three variables but were statistically different for the last two variables. The students who completed the end-of-term survey rated the following variables higher, on average: how often do you predict you will attend class this semester and which of the following statements reflects how you feel about attending class. The higher scores reflect student intention to attend more classes and a more positive sentiment toward the class.

Of the students who opted to complete the baseline survey, 41% reported they were comfortable using digital tools in the classroom and 85% agreed that digital tools could enhance their learning in class. The students who consented to participate in the study seemed to be moderately motivated, with 49% indicating that they expected to spend more than 6 hours a week outside of course time studying and 57% indicating that they planned to attend every class without exception. Sixty-one percent of the students who opted to complete the end-of-term survey were female. The majority of the students who took the end-of-term survey were also freshman (61%), followed by sophomores (23%), juniors (11%), and seniors (2%), respectively.

**Methodology.** Comprehensive data were collected for a mixed methods analysis. Student and instructor surveys were administered at the beginning and end of the semester, and instructor classroom observations were conducted midsemester along with a formal instructor interview protocol. Product use data and student academic performance data were collected. Data were matched across sources, and descriptive and correlational analyses were conducted. A complete description of the collected data has been included below.

**Student presurvey.** This survey was administered online during the first month of the courses. Five scales were tested for psychometric soundness during a pilot study. One scale asked about student comfort with technology, one scale asked about student sentiment toward technology use in the classroom, one scale asked about academic behaviors outside of class, one scale asked about classroom behavior, and the final scale asked about student sentiment toward the course.

**Instructor presurvey.** A survey that asked instructors to report on background and demographic characteristics was administered online during the first month of the courses. The survey included a scale that measured the instructors' acceptance of technology and included items about comfort with technology, perceptions about use of technology in the classroom, intended implementation of iClicker Reef, intended implementation of other publisher-provided digital learning tools or open educational resources, and general perceptions of iClicker Reef.

**Classroom observations.** All instructors were observed using iClicker Reef in at least one of their classes midway through the semester. During these observations, the classroom environment and the technology available to both students and instructors were noted. Use of iClicker Reef was meticulously documented to include the type of questions asked, student response rates, the devices student used, and instructor methods for sharing data and/or feedback with students.

**Instructor interviews.** An instructor interview protocol was developed based on the research questions. Probes were developed in real-time based on responses to questions in the interview protocol.

**Student postsurvey.** A survey was administered online during the last three weeks of the semester. The survey asked students to share demographic data, personal device data, their perceptions of iClicker Reef, how they used iClicker Reef, their engagement in the course<sup>1</sup>, their satisfaction with the course and iClicker Reef, and a System Usability Scale<sup>2</sup>.

**Product use data.** The following data were extracted from the iClicker Reef platform: questions the instructors asked using iClicker Reef, type of iClicker questions asked (i.e. multiple-choice, numerical item, short answer, or target), the students' responses to each question (whether they responded or did not), coded point for correct or incorrect student response (available only if the instructor coded the correct answer), number of questions presented per class or iClicker Reef session, number of questions answered per class, and number of questions answered correctly per class (available only if the instructor coded the correct answer).

**Student course performance data.** Instructors were asked to share the following course performance data: homework scores, quiz scores, exam scores, final exam scores, final course grades and percentages, attendance rate, and participation scores. Instructors were not asked to change their regular course performance methods so not every variable was available for each instructor. For example, some instructors did not score homework or give quizzes so they only reported exam scores and final course grades.

## Findings

The results of this study have been presented by research question.

**How is iClicker Reef being used within and across educational environments? What are the motivations for use cases? Is there a difference in use by type of mobile device?**

### **Across educational environments.**

Six instructors across five institutions used iClicker Reef in this study. Five of the six instructors were members of STEM departments and taught STEM courses (physics, chemistry, biology, or math), while one instructor taught psychology. In this section,

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<sup>1</sup> Handelsman, M. M., Briggs, W. L., Sullivan, N., & Towler, A. (2005). A measure of college student course engagement. *The Journal of Educational Research*, 98 (3), 184-191.

<sup>2</sup> Brooke, J. (1986). System Usability Scale. Digital Equipment Corporation.

we have presented implementation across educational environments followed by implementation across instructors.

Of the six instructors in the study, two instructors allowed their students to access iClicker Reef in the classroom with any device available to them—an iClicker remote, mobile device, or a laptop. Two instructors allowed iClicker remotes and mobile devices but preferred that laptops not be used. Two instructors allowed mobile devices and laptops but did not allow iClicker remotes to be used.

Across the instructors, a mean of 276 ( $SD = 94$ ) iClicker questions were asked during the semester. The amount of questions asked across instructors varied with one instructor asking only 139 questions and another asking 438 questions. Of the questions presented to students, an average of 7 ( $SD = 5$ ) were answered each session across instructors; there was an average of 1 to 18 questions presented per session. Students answered a mean of 67% of the questions presented each session. Instructors used multiple-choice questions the most frequently (75%), followed by numerical (14%), short answer (8%), and target questions (3%).

Students primarily accessed iClicker Reef through a mobile device or laptop (61%), followed by the iClicker remote (30%). Eight percent of students used a combination of devices. Of the students who reported using either a mobile device or laptop, 60% used a mobile device, 20% used laptops, and 20% chose not to say which device they used. For students who used a mobile device to access iClicker Reef, 69% used an iPhone, 23% used an Android, and the remainder used some other mobile device. There was no evidence of any difference in iClicker use based on type of mobile device used. Students were able to equally participate in polling across device types. One instructor reported being limited to certain types of iClicker questions because some students used iClicker remotes; students who used iClicker remotes could not respond to target questions.

All instructors tried to use iClicker Reef during each class and were largely successful with the exception of the classes held during the first and second weeks of the semester when students were still registering. Four of the six instructors used iClicker Reef strictly to track student participation credit. Students were required to respond to iClicker questions and received credit for participating that day if they did, which ultimately contributed to a certain percentage of their grade; depending on the instructor, participation credit accounted for 5–20% of the students' final course grade. These instructors may have coded correct and incorrect answers in the iClicker Reef system, but the instructors did not require that students answer the questions



correctly to receive participation credit. One instructor required that students answer questions correctly in order to receive credit. This instructor calculated the amount of correct iClicker responses over the course of the semester and turned the score into a quiz grade. One instructor used iClicker to track participation and measure the accuracy of the students' responses. Ninety percent of the students' iClicker Reef score was earned by simply responding to the question, while 10% of the score was earned by responding correctly.

All instructors indicated that they used iClicker Reef for classroom polling. During classroom observations, the majority of the instructors shared the graphs displaying classroom results despite the fact that most of the instructors did not score responses. The graphs were used to show students how their responses compared to their classmates, to generate classroom discussions, or to provide additional support from the instructor when needed. Two instructors also used iClicker to track attendance. Neither of these instructors was using the geolocator feature when they submitted the survey.

### **Within educational environment.**

#### **University of Central Florida**

This instructor began teaching large Introduction to Psychology classes the previous semester and chose to incorporate iClicker Reef into lessons to increase communication with students. The instructor chose to use the cloud version of iClicker because it offers more item types than multiple-choice. The instructor also liked that both the course textbook and iClicker are produced by Macmillan Learning. The instructor wanted to use iClicker to encourage student participation in a manner that did not require students to answer a question correctly in order to receive participation credit. iClicker allowed the instructor to give students credit for responses regardless of whether their responses were correct.

The instructor used iClicker to track student participation credit. Students were required to answer at least 75% of the questions to receive a 1-point participation score. They received the participation point regardless of whether they answered the questions correctly. Participation credit accounted for 5% of the students' final course grade. The instructor presented iClicker questions to students in 93% (14 out of 15) of the classes with a total of 248 iClicker questions asked over the course of the semester. In addition, the instructor used iClicker to review for exams. During the class prior to the exam, the instructor awarded bonus points to students who

answered the review questions correctly. Eighty-five percent of the iClicker questions were multiple-choice, 8% were short answer, and 7% were target.

### Boise State University

Boise State University chose iClicker Reef as their institution-wide student response system and they provided support for instructors and students who used iClicker Reef. This instructor used iClicker Reef to increase student interaction. The instructor believed that students who use iClicker Reef pay more attention in class because they know questions will be presented throughout the lecture. Since the instructor weighted iClicker responses to account for 20% of the students' final course grade, students understood the importance of participating during lectures and how the learning tool could affect their own learning. The instructor taught two sections of physics—I and II—classes.

The instructor used iClicker Reef to track student participation credit. Students were required to answer at least 50% of the questions in each class to receive participation credit for that class. They received the credit regardless of whether they answered the question correctly. Participation credit accounted for 20% of the students' final course grade. The instructor presented iClicker questions to students in 89% (39 out of 44) of the Physics I classes with a total of 230 questions asked over the course of the semester. Seventy-nine percent of the questions were multiple-choice and 21% were numerical items. The instructor presented iClicker questions to Physics II students in 89% (39 out of 44) of the classes with a total of 220 questions asked over the course of the semester. Eighty-three percent of the questions were multiple-choice and 17% were numerical items.

### University of Waterloo

This instructor taught very large Introduction to Cell Biology classes. The instructor used iClicker Reef to facilitate communication with students and to check for student understanding. The instructor strictly used multiple-choice questions and created the questions to give students insight into how their exam would be structured. The instructor did not release the iClicker questions directly to students. Instead, the instructor projected them onto a screen at the front of the class. The instructor did not release the questions directly to students due to a belief that students who attended earlier class times might share the questions with students who attended later class times. The instructor believed that iClicker Reef provided a quick overview

of whether students were grasping the material and that it helped students discover if they understood the lessons.

The instructor used iClicker to track student participation credit and attendance. Students were required to answer at least 75% of the questions to receive a 1-point participation score. They received the participation point regardless of whether they answered the question correctly. Participation credit accounted for 5% of the students' final course grade. The instructor used iClicker Reef in every class except the first one and presented a total of 438 questions over the course of the semester. One hundred percent of the iClicker questions were multiple-choice. As long as students answered one question per session, they were also given credit for attending the class.

### University of Wisconsin-Eau Claire (Physical Science Instructor)

The University of Wisconsin-Eau Claire chose iClicker Reef as their preferred student response system. The university provided technical support for instructors who used the product. The Physical Science department asked all their instructors to use iClicker Reef similarly to ensure consistency in how grades were awarded. This instructor opened each class by using iClicker to review material from the previous lecture. After ensuring students had mastered previous material, the instructor presented new class material. The instructor used iClicker throughout the lecture to check for student understanding of new concepts. The instructor encouraged students to discuss the questions presented and work together to solve them. The instructor reviewed the students' responses to check for understanding and planned to review class material if fewer than the majority of students answered the questions correctly. The instructor required that students use either iClicker devices or mobile devices to respond to iClicker questions—the instructor did not allow laptops or tablets to be used during class.

The instructor used iClicker Reef to track participation and performance, as well as attendance. Students were required to answer all of the questions presented to them during each class. iClicker questions accounted for 5% of the students' final course grade. When a student answered an iClicker question, they received 90% of their participation points, and they received the remaining 10% if they answered the question correctly. The instructor believed this scoring method would ensure students took the questions seriously. The instructor also tracked attendance with iClicker Reef. Attendance did not contribute to the students' final course grade. However, the instructor reviewed attendance if a course grade was borderline and took attendance into account when assigning the final course grade, so it was

important that the information was correct. The instructor presented iClicker questions to students in 71% (30 out of 42) of the classes with a total of 142 questions asked over the course of the semester. One hundred percent of the iClicker questions were multiple-choice.

### University of Wisconsin-Eau Claire (General Physics Instructor)

This instructor presented iClicker questions to introduce concepts and start a dialogue with students. The instructor believed the most effective way to use iClicker was to ask questions and then have students discuss the reasoning behind their answers with a classmate. Students were asked to discuss why their conclusions may have differed with a classmate and then to come back together as a class to discuss what they learned from each other and the available iClicker data.

The instructor used iClicker Reef to track participation credit. Students were required to answer at least 75% of the questions presented to them each class to receive credit for participating that day. iClicker questions accounted for 5% of the students' final course grade. The instructor used iClicker in all of the classes with a total of 165 questions asked over the course of the semester. One hundred percent of the iClicker questions were multiple-choice.

### Merced College

This instructor taught Introductory Chemistry and Intermediate Algebra using iClicker Reef. The instructor used a flipped classroom teaching technique. The instructor assigned text for the students to read prior to class. During class, the instructor presented iClicker questions that were related to the text to students, and as a group, they solved and discussed the questions. The instructor used all questions types available in iClicker Reef (multiple-choice, numerical items, short answer, and target). The instructor also used iClicker both in the classroom and in labs. The instructor believed the learning tool provided a measure of student understanding, helped engage students, and allowed for better management of the pacing of the class.

The instructor used iClicker Reef to track student performance. The instructor used a flipped classroom teaching technique, and iClicker questions guided classroom instruction. Students were expected to read material from their texts prior to class and to be prepared to discuss that content in class. iClicker questions were presented to students throughout the class, and students were required to answer the questions correctly to receive a point. All iClicker points were totaled over the course of the semester and used as a quiz grade. The instructor also used iClicker responses

to track attendance, but a point value was not associated with attendance. The instructor simply tracked students with a large number of absences to inquire about whether they dropped the class without providing notification. The instructor presented iClicker questions to Intermediate Algebra students in 88% (29 out of 33) of the classes with a total of 272 iClicker questions presented over the course of the semester. Forty-six percent of the questions were multiple-choice, 14% were short answer, 4% were target, and 36% were numerical items. There were two sections to the chemistry class (at 8 a.m. and 9 a.m.). The instructor presented iClicker questions to students in 92% (43 out of 47) of the classes with a total of 387 iClicker questions in the 8 a.m. class and 354 questions in the 9 a.m. class over the course of the semester. In the 8 a.m. class, 48% of the questions were multiple-choice, 22% were short answer, 5% were target, and 25% were numerical items. In the 9 a.m. class, 49% of the questions were multiple-choice, 21% were short answer, 5% were target, and 25% were numerical items.

**How is use of iClicker Reef related to student learning, student engagement, and student satisfaction with the course? Is there variability across different use cases?**

There was a statistically significant positive correlation (.226) between use of iClicker Reef and student learning. Use of iClicker Reef was quantified by the number of questions that students answered over the course of the fall 2017 semester. Student performance was measured by the students' final course grade in percentage form. The positive correlation, although low, indicates that students who answer more iClicker questions have higher course performance. Conversely, students who answer fewer questions tend to have lower course performance.

A second correlation was calculated using either a combination of number of iClicker questions answered correctly (for the two instructors who scored iClicker questions) or number of questions answered (for the other four instructors who did not score) and student performance. This correlation was also statistically significant and higher at .376. The higher correlation likely indicates the importance of quantifying use of iClicker by the type of use expected in each classroom (e.g. if students only receive credit for correct responses then quantify by number of correct responses, if the instructor only calculates the number of responses then do not score answers, etc.).

A 23-item student engagement survey, the Student Course Engagement Questionnaire (SCEQ), was administered during the last three weeks of the semester via SurveyGizmo. The survey represented four factors of student engagement: skills

(engagement through practicing skills), participation and interaction (engagement through participating in class and interacting with the instructor and other students), emotional (engagement through emotional engagement with class materials), and performance (engagement through levels of performance in the class). Students responded to the items using a Likert Scale of 1–5 (ranging from “not characteristic of me at all” to “very characteristic of me”), and responses were totaled to calculate a student engagement score. The student engagement score was correlated with the students’ final course grade. There was a positive, statistically significant correlation of .253 between student engagement and course performance. While the correlation was relatively low, it indicates that students who rate themselves as more engaged tend to have higher course grades.

A 16-item student satisfaction survey was also administered during the last three weeks of the semester via SurveyGizmo. The 16 items were derived from a 23-item survey that measured student perception of clickers as an instructional tool to promote active learning in the classroom and student satisfaction with clickers in their class. There was a very low correlation (.072) between student satisfaction and student course performance. The correlation indicates there is no discernable trend in how satisfied students are with clickers and their course performance.

### University of Central Florida

There was a significant positive correlation (.557) between the amount of iClicker questions students answered and their performance in the course. Students who answered more iClicker questions tended to have higher overall course grades. Conversely, students who answered fewer iClicker questions tended to have lower course performance. There was a low correlation (.110) between student engagement and course performance and between student satisfaction and course performance (.017).

### Boise State University

There was a significant positive correlation (.539) between the amount of iClicker questions students answered and their performance in the Physics I course. There was also a significant positive correlation (.433) between the amount of iClicker questions students answered and their performance in the Physics II course. There was a low negative correlation (-.150) between student engagement and course performance for the Physics I course and also between student satisfaction and course performance (-.092). There was a high positive correlation (.762) between student engagement and course performance for the Physics II course and a

moderate negative correlation (-.486) between student satisfaction and course performance.

### University of Waterloo

There was a statistically significant low positive correlation (.209) between the amount of iClicker questions students answered and their performance in the course. Students who answered more iClicker questions tended to have higher overall course grades. Conversely, students who answered fewer iClicker questions tended to have lower course performance. There was also a significant positive correlation (.325) between student engagement and course performance and a very low correlation (.036) between student satisfaction and course performance.

### University of Wisconsin-Eau Claire (Physical Science Instructor)

There was a significant positive correlation (.511) between the amount of iClicker questions students answered correctly and their performance in the course. There was also a low negative correlation (-.236) between student engagement and course performance and a very low negative correlation (-.066) between student satisfaction and course performance.

### University of Wisconsin-Eau Claire (General Physics Instructor)

There was a low positive correlation (.145) between the amount of iClicker questions students answered correctly and their performance in the course. There was also a very low correlation (.035) between student engagement and course performance and a low negative correlation (-.273) between student satisfaction and course performance.

### Merced College

There was a significant positive correlation (.735) between the amount of iClicker questions students answered correctly and their performance in the chemistry courses. There was also a significant positive correlation (.402) between student engagement and course performance and a low positive correlation (.250) between student satisfaction and course performance.

There was a significant positive correlation (.802) between the amount of iClicker questions students answered correctly and their performance in the Intermediate Algebra course. There was a positive correlation (.548) between student engagement

and course performance and virtually no correlation (.002) between student satisfaction and course performance.

**What iClicker Reef question types are being asked in class, and what is the variability in learning performance based on question types?**

**Table 1. Question Types by Instructor/Course**

Instructor/Course	Multiple-choice	Numerical item	Short answer	Target	Correlation of usage to learning
University of Central Florida: Introduction to Psychology	85%	0%	8%	7%	.557
Boise State University: Physics I	79%	21%	0%	0%	.539
Boise State University: Physics II	83%	17%	0%	0%	.433
University of Waterloo: Introductory Cell Biology	100%	0%	0%	0%	.209
University of Wisconsin-Eau Claire: Physical Science	100%	0%	0%	0%	.511
University of Wisconsin-Eau Claire: General Physics	100%	0%	0%	0%	.145
Merced College: Introductory Chemistry (8 a.m.)	48%	25%	22%	5%	.735
Merced College: Introductory Chemistry (9 a.m.)	49%	25%	21%	5%	.735
Merced College: Intermediate Algebra	46%	36%	14%	4%	.802

The Merced instructor had the most variability in types of questions asked and also had the highest correlations of use of iClicker Reef to student performance (.735-.802). Two of the three instructors (the University of Waterloo instructor and the



University of Wisconsin-Eau Claire General Physics instructor) who strictly used multiple-choice questions had the lowest correlations to learning performance (.145-.209). However, one instructor who strictly used multiple-choice questions (the University of Wisconsin-Eau Claire Physical Science instructor) had a moderately high positive correlation to learning performance (.511). The two instructors who primarily used multiple-choice questions but also mixed in other types had moderately high correlations as well (.433-.557). While the design of this study does not permit causal inferences to be drawn, the general trend of higher correlations associated with varied types of questions and lower correlations associated with strictly using multiple-choice questions is interesting to note. The one instructor who strictly used multiple-choice questions and had a moderately high correlation also scored questions whereas the other instructors who used strictly multiple-choice questions did not score questions. Perhaps this explains how the instructor achieved a high correlation to learning while strictly using one type of question.

**Is use of iClicker Reef to facilitate class interaction (i.e. asking opinions, soliciting feedback) associated with a different relationship to student performance as compared to using iClicker Reef for formative assessment (i.e. actually testing the students' knowledge)?**

**Table 2. Instructor Choice of Formative Assessment Usage and Student Learning**

Instructor/Course	Formative assessment	Correlation of usage to learning
Merced College: Intermediate Algebra	Yes	.802
Merced College: Introductory Chemistry (8 a.m.)	Yes	.735
Merced College: Introductory Chemistry (9 a.m.)	Yes	.735
University of Central Florida: Introduction to Psychology	No	.557
Boise State University: Physics I	No	.539
University of Wisconsin-Eau Claire: Physical Science	Yes	.511
Boise State University: Physics II	No	.433
University of Waterloo: Introductory Cell Biology	No	.209
University of Wisconsin-Eau Claire: General Physics	No	.145

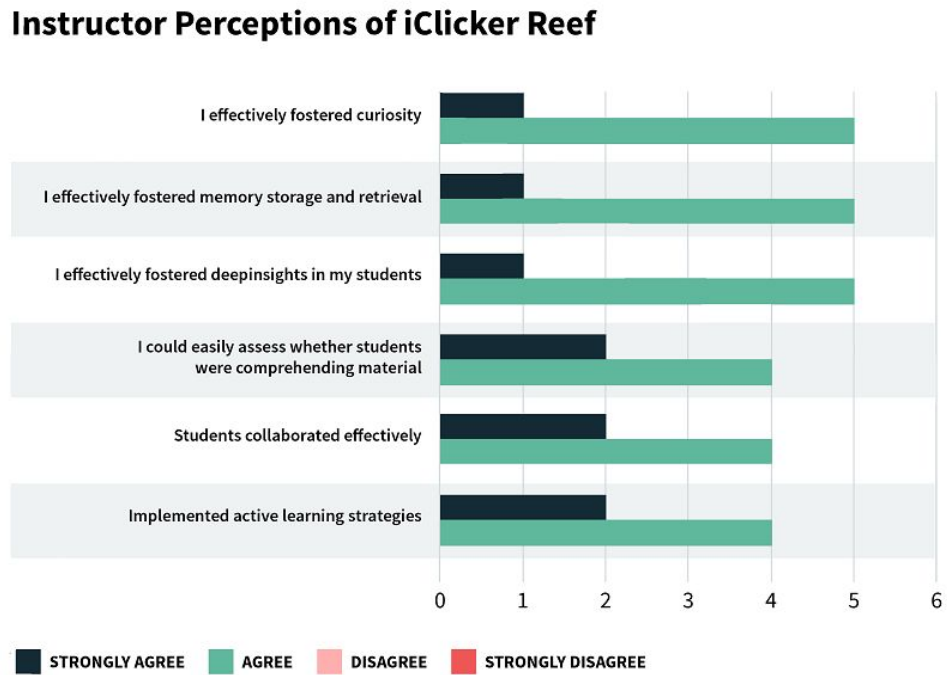
The Merced College instructor, who taught chemistry and math, was the only instructor in the study who used iClicker questions as a quiz grade. The other instructor who scored items only devoted 1/10 of a point for accuracy and the other 9/10 of the point was credit for answering the question regardless of whether the response was correct. The four remaining instructors did not score items or consistently share the correct answers with students during class. Table 2 shows that the Merced instructor had the highest positive correlations between use of iClicker Reef and student performance when compared to the other instructors. The instructor who offered 1/10 of a point for accuracy also had a moderately high correlation to learning; however, this correlation was lower than the two instructors who did not use iClicker for formative assessment.

### **What are instructor and student perceptions of iClicker Reef?**

#### **Instructor perceptions.**

Instructors were generally positive in their perceptions of iClicker Reef. All instructors “agreed” to “strongly agreed” that iClicker Reef helped foster student curiosity, memory storage and retrieval, and deep insights. In addition, the learning tool helped instructors easily assess student comprehension and encouraged student collaboration and active learning.

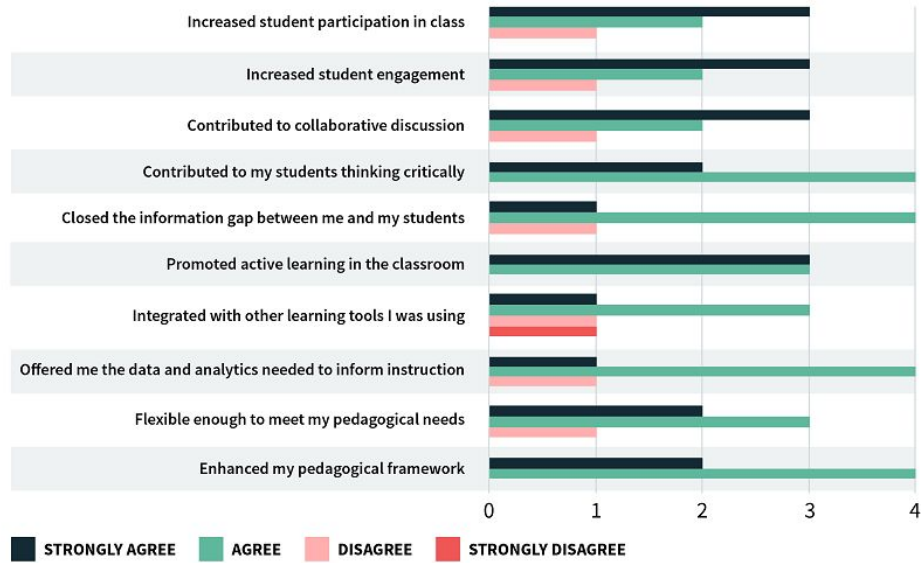
**Graph 1. Instructor Perceptions of iClicker Reef**



The majority of the instructors also agreed that iClicker Reef helped facilitate active learning in the classroom and student engagement (see Graph 2). One instructor did not approve of using mobile devices in the classroom. The instructor felt that use of mobile devices in the classroom has the potential to distract students because they can access other websites on those devices instead of paying attention to the lecture. In future semesters, the instructor will consider allowing students to only use iClicker remote devices to avoid this potential distraction. All instructors agreed that iClicker helped students think critically, promoted active learning in the classroom, and enhanced their pedagogical framework.

**Graph 2. Instructor Perceptions of iClicker's Contribution to Active Learning**

### Instructor Perceptions of iClicker's Contribution to Active Learning



Instructors were asked via an open-ended question the most effective way to use iClicker. The majority of the instructors used the learning tool to stimulate discussions with their students so they could understand if students understood the content presented to them. One instructor reported using the tool to simulate the type of questions that would appear on exams in order to better understand student mastery of topics depending on question type (i.e. multiple-choice, open response, etc.) and level of reasoning (i.e. Bloom's Taxonomy Scale) expected.

All but one instructor reported that iClicker Reef was easy to use and that they liked to use it frequently. Instructors were also asked to rate iClicker Reef via the Net Promoter Score (NPS). The NPS is an index ranging from -100 to 100 that measures the willingness of customers to recommend a company's products or services to others. Given the NPS range of -100 to 100, a score above 0 is considered "good," a score above 50 is considered "excellent," and a score above 70 is considered "world class." The instructors in this study rated iClicker Reef at a NPS of 16, which is considered "good."

#### Student perceptions.

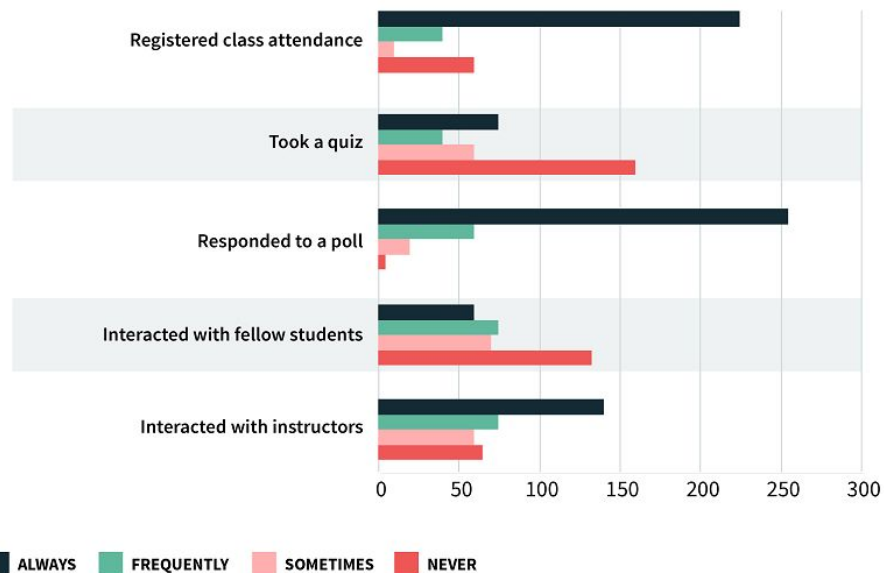
Student feedback about iClicker Reef was also generally positive. Students took an end-of-semester online survey to measure ways of using iClicker Reef in class,

engagement and satisfaction with the course, ease of use, and their general perceptions of iClicker Reef.

Students reported that they used iClicker Reef in class for a variety of activities, including registering class attendance, taking quizzes, responding to polls, and interacting with fellow students and their instructor. The majority of students indicated that they always used iClicker Reef to register their attendance in class and to take a poll. Fewer students used iClicker Reef to take quizzes and to interact with fellow students. Graph 3 shows the frequency of the students' responses by class activity.

**Graph 3. Use of iClicker Reef for Class Activities**

### Use of iClicker Reef for Class Activities



The survey results indicate that students were satisfied with their course and iClicker. On a 4-point scale (“strongly disagree” to “strongly agree”), student mean satisfaction was 3.15 ( $SD = 0.55$ ) meaning students “agreed” to “strongly agreed” that they were satisfied with their course.

The engagement scale rated student engagement on four factors as well as tracking overall engagement. The four factors were as follows: skills engagement, emotional engagement, participation and interaction engagement, and performance engagement. Students rated statements on a 5-point scale ranging from “not at all

characteristic of me” to “very characteristic of me.” Overall, students reported that they were moderately engaged in their class. The mean ratings on each scale as well as the overall engagement level have been presented in Table 3.

**Table 3. Student Mean Engagement Levels**

<b>Scale name</b>	<b>Mean rating</b>
Skills engagement	3.5
Emotional engagement	3.1
Participation and interaction engagement	2.7
Performance engagement	3.6
Overall engagement	3.3

Students were asked to rate their level of engagement with the class specifically due to using iClicker Reef on a scale of 1 (“not at all engaged”) to 4 (“very engaged”). The average rating was 2.7 which indicates that students were “somewhat engaged” to “engaged.” Students were then asked to rate their level of engagement compared to other courses they were taking during the semester on a 5-point scale (“less engaged than in other courses” to “a lot more engaged than in other courses”). The average rating was 2.9 which indicates that students had about the same level of engagement in the course using iClicker Reef as in other courses.

Students considered iClicker Reef to be easy to use. The System Usability Scale was administered to students at the end of the semester. Students rated iClicker Reef 72.69 on the scale. Scores above 68 points are considered “above average” in terms of system usability.

When asked to report their favorite use of iClicker Reef through an open-ended question, 19% of students reported that they enjoyed using the learning tool for questions and answers. Twelve percent reported that they enjoyed polling, 8% enjoyed taking quizzes, and 7% enjoyed checking their retention of information. A couple other notable activities were reviewing practice questions (5%) and answering sample questions for their exams (4%).

Students were also asked to report their least favorite use of iClicker. Twenty-seven percent of students reported that there was nothing they did not like, 13% reported that the question was not applicable, 9% reported that they did not enjoy taking attendance with iClicker, 6% reported connectivity issues or technical problems, and 6% reported that they did not enjoy taking quizzes.

## Notes

The results of this study suggest that use of iClicker Reef relates to student performance, particularly if instructors score their students' responses and share response graphics. Instructors tend to find iClicker Reef to be easy to use and recommend its use to their colleagues. Students also report that iClicker Reef is easy to use—they are both satisfied with and engaged in their courses that use iClicker Reef. Although the results of this study alone cannot be generalized beyond these instructors, this study provides rich context of specific use cases and the results the instructors and students achieved.

The research brief associated with this study can be found here:  
[macmillanlearning.com/catalog/page/learningscience](https://www.macmillanlearning.com/catalog/page/learningscience)