Clickers versus Plickers: Comparing Two Audience Response Systems in a Smartphone-free Teaching Environment

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Abstract

This study compared the performance of two audience response systems (ARS) without students requiring smartphone technology or Internet access during problem-based learning (PBL) activities. Clicker handsets linked to a radio frequency (RF) receiver and paper voting cards, known as Plickers, which display a QR code (two-dimensional barcode) that can be captured by the instructor using a standard camera on a tablet device, represent two audience response platforms that allow students to vote in classrooms where smartphones are prohibited. Following regular usage of both by 157 first-year undergraduates, the proportion of the cohort voting with each polling platform was compared across 65 polling events as a measure of student compliance and engagement, and by deduction ARS performance.

Results from this study showed that both clickers and Plickers achieved satisfactory cohort compliance rates of 87.22% and 78.26%, respectively. Anonymous student survey data overwhelming favored the clicker handsets over the Plicker voting cards, which was, in part, justified by clicker usage being more self-explanatory than that of Plickers, however, from an instructor’s perspective, both voting platforms adequately captured the level of students’ understanding during interactive sessions where problem-solving opportunities were embedded whilst maintaining a smartphone-free environment.

Graphical Abstract



Keywords

First-Year Undergraduate / General, Laboratory Instruction, Organic Chemistry, Problem Solving / Decision Making, Acids / Bases, Chirality / Optical Activity, Nomenclature, Reactions, Reaction Intermediates

Introduction

Previous work by both the author and others has shown how PBL sessions embedded with voting technology enable the learner and instructor instant access to individual and cohort feedback.1-10 In addition, such technology can positively impact students’ engagement and short-term learning whilst also promoting peer instruction. Clearly, the incorporation of any technological tool should primarily focus on assisting the classroom’s pedagogical goal without impeding the flow or creating an added distraction.11,12 In this study, the pedagogical goal was to create and maintain an interactive, engaging environment where students could practice their problem solving techniques in fast moving PBL sessions that offered rapid feedback on what the students did and didn’t know while also enabling the learner to gauge their own performance against that of their peers using two different voting platforms.

Smartphone-free voting platforms of the type used in this study help ensure that students are engaging with both their work and peers within these problem solving sessions rather than relying on access to web-based search engines, which may hinder the learning experience and create a distraction, especially in large classroom environments where use on off-topic tasks is harder to monitor.13-18 Smartphone-free voting is also preferable when working with students in chemistry labs where mobile phone usage is often prohibited on safety grounds.

A PBL environment embedded with individual or team-based polling undoubtedly relies on the efficient, seamless use of an appropriate ARS. Although 100% response rates remain feasible with such polls, obtaining votes for approximately 80% of the cohort is adequate when attempting to monitor the cohort’s level of understanding. This is because the slowest 20% of cohort responders frequently guess their answer while also hindering the flow of classroom sessions.19,20

The aim of this study was to compare student engagement with two smartphone-free polling platforms. This was evaluated using cohort voting data from pharmacy and pharmaceutical science students (N=157) who individually answered multiple-choice questions (MCQs) on their first-year undergraduate chemistry content during many different teaching sessions. In addition to monitoring the efficiency with which student votes were captured, based on the proportion of votes lodged for each MCQ, the opinions of the student body were surveyed after repeatedly alternating between the two voting platforms during a full semester of study.

Methodology

First-year pharmacy and pharmaceutical science undergraduates (N=157) on a co-taught module were all equipped with both a Turning Technologies RF LCD (liquid crystal display) clicker handset and an A5 laminated Plicker voting card displaying a unique QR code. The Plicker app and QR cards were downloaded free of charge from [www.plickers.com](http://www.plickers.com).21 In all cases only one voting platform was used in any given session and to ensure consistency, all sessions were delivered by the same instructor. In total, over the course of one semester, 35 different MCQs were used in 65 polling events to cover chemistry material on acids and bases, chirality, nomenclature and organic reactions.

The keypads on the RF LCD clicker handsets allowed MCQs containing up to 10 different answers, whilst the Plicker cards were restricted to MCQs with four possible answers, with one side of the 8.2cm x 8.2cm square QR code representing either A, B, C or D. All Plicker card answers were determined solely by how the card was held. Rotating the Plicker card through 90, 180 and 270 degrees clearly allowed the other MCQ options to be selected (see figure 1). Each Plicker card was captured using an 8M pixel camera on the instructor’s tablet device over distances up to 15 meters away and all camera captured cards then had their responses translated into MCQ answers using the Plicker app. For both the clickers and Plickers, students could change their answer during polling with the last response overriding any prior vote.



Figure 1. Illustrating the four ways that a Plicker card can be held when voting for either option A, B, C or D.

In this work, all captured data were treated anonymously and were deliberately managed to prevent traceability to an individual student. For Plicker votes, students were asked to hold up their Plicker cards with the QR code facing the instructor, who would then capture the response using the camera feature on their tablet device. In all cases the instructor moved either side of the lectern to ensure all votes were collected. This was especially important in flat-floor teaching venues where some cards were blocking others from immediate view.

Due to the large cohort size (N=157), while all lectures were typically delivered to the full cohort (as a 100% group), smaller groupings were used for problem classes, which were delivered as two separate sessions (one for each 50% group within the full cohort). In contrast, based on flat-floor venues having smaller capacities, workshops and labs were delivered in triplicate with each group representing 33% of the entire class. Three identical Plicker packs were required to supply the full cohort since only 63 different Plicker card combinations were available. Plickers were therefore reserved for MCQ voting that featured when in the 33% groupings to ensure all students had a different QR code in a given session. In contrast, clicker handsets were used during the 100% and 50% group sessions. The duration of teaching sessions ranged from 1-3 hours, with problem classes and workshops containing a higher frequency of voting opportunities while lectures and labs contained no more than four polls per hour, consistent with the pedagogical literature on the best voting practices.1,22,23 During all such sessions students were prohibited from smartphone or Internet access.

For uniformity, all sessions involving student polling were designed with a primary focus on PBL and were timetabled over the first semester of teaching at regular intervals to ensure students became familiar with both voting platforms. Cohort compliance with each voting platform was based on the total number of responses received per question and was calculated as a percentage of the maximum possible compliance using class attendance figures for the given session, which were taken from the electronic register data generated by students swiping their institutional student card upon entry to each timetabled session. Cohort feedback was obtained at the start of week 14 and was captured using the clicker handsets. In addition, two focus groups, each consisting of four different students from the cohort, were used to help anonymously explain the cohort feedback and to provide qualitative data. These group discussions were held after the students had completed their first year of study to ensure all students had experienced a wide range of teaching styles to help them make more informed comments and reflect more broadly. Students were asked to share their own personal experiences, while also being encouraged to try and explain the cohort feedback based on their observations and conversations with peers during and after PBL sessions. This feedback process was entirely voluntary with no incentives offered to students who participated.

Results

Table 1 outlines the key findings of this comparative study with mean cohort compliance rates of 87.22% and 78.26% when using clickers and Plickers, respectively. These data, which were based on a total of 65 polls show there was no significant response rate difference between the two polling platforms (*p*>.1) with both achieving rates around 80%, which meets the required threshold for meaningful audience response data on the cohorts’ level of understanding for the taught topic.19,20 The slightly higher standard deviation value for Plicker compliance rates (8.76%) versus that for clickers (7.24%) may be explained by the flat-floor venues that were used for some 33% group sessions, which in certain situations may have made the camera view more difficult to capture all Plicker responses (*cf.* to camera views in tiered teaching venues). This, however, was unavoidable for lab sessions that required the use of flat-floor facilities. Alternatively, this wider response range could be linked to Plickers’ usage in smaller group sessions (33% groups) where an individual student’s decision whether or not to engage in voting obviously had a bigger influence on the overall response rate data.

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| Table 1. Comparing clicker & Plicker performance |
| Cohort data | Clicker handsetsa | Plicker voting cardsb |
| **From a variety of teaching sessions (*N*=157)** |  |  |
| Average response rate to MCQs | 87.22%c  | 78.26%d |
| Standard deviation | 7.24%c | 8.76%d |
| **From student evaluationse** |  |  |
| Mean student feedback score (out of 10) | 8.33 (*N*=84) | 3.86 (*N*=79) |
| Median student feedback score (out of 10) | 9.00 (*N*=84) | 4.00 (*N*=79) |
| Preferred voting platformf | 91.36% (*N*=81) | 1.23% (*N*=81) |
| aClicker handsets were used in lectures and problem classes involving 100% & 50% of the student cohort. bPlicker voting cards were used in workshops and lab sessions involving 33% of the student cohort. cData collected from 5 different teaching sessions involving a total of 38 polls. dData collected from 9 different teaching sessions involving a total of 27 polls. eStudent evaluations were collected in week 14 using the clicker platform, after all teaching sessions had taken place. Students were asked to score both clicker and Plicker PBL sessions (10 = highest score, 1 = lowest score). fStudents were also asked to choose between the two voting platforms based on their preference and were given the option of selecting clickers, Plickers or stating no preference; 7.41% selected the latter. |

Using the two voting platforms for different types and sizes of session may be considered a limitation of this study and may also in part explain the student feedback in support of clickers over Plickers (see table 1). Nevertheless, with such an overwhelming student preference for clickers this limitation cannot be considered the only contributory factor, since scores of 90% in support of clicker-based learning have been reported previously across a wide range of teaching formats.9,10 The cohorts’ Plicker feedback score of around 4 out of 10 is surprisingly low (*cf*. 9 out of 10 for clickers) and not representative of what was observed in sessions involving Plicker use; where students appeared to engage and enjoy the interactive nature of Plickers in a similar manner to when using clickers. Instead, it is likely that these low scores are reflective of the students directly comparing the two platforms, which after all, was the intention of this study. It is however, plausible that a score higher than 4 would be achieved if trialing Plickers as the only voting system since a clear eagerness by students to participate was observed, and this is reinforced by the response rate data and findings by others.24,25

Discussion

From a comparative viewpoint based solely on cohort response rates (see table 1) both polling models achieved sufficient data to reliably represent the cohort and demonstrate student compliance during these PBL sessions. As a result, for faculty with restricted financial resources the Plicker system, with negligible associated costs, may provide greater appeal.26,27 In laboratory sessions, where digital devices are usually prohibited, the economic and practical benefits of Plickers were particularly noticeable, as laminated Plicker cards were able to assess the level of student understanding while being easy to replace or clean following any chemical spillages during classes. Similarly, it has been shown that Plickers can have practical advantages in physical education settings, such as gymnasiums for example, where students with no access to writing materials or digital devices could still freely vote.28,29

In contrast to Plickers, clicker usage enabled much bigger classes and a wider variety of question types to be polled, including MCQs with more than four response options. In this work clickers were certainly preferred by the instructor when collecting data in flat-floor teaching venues where the line of sight between the instructor and student was obscured. In addition, clicker polling occurred seamlessly during PowerPoint presentations without the need to switch between software, which was necessary when using Plickers. Furthermore, the data management system used by clickers was found to be far more sophisticated and user-friendly than that associated with the freely available Plicker software. This should, however, be balanced against the required annual payment for an instructor’s clicker license along with the one-off cost for the clicker handsets and RF receiver. Moreover, when students forgot to take their clicker handset to class, providing a replacement was deemed to be less economically feasible than when the same scenario arose during sessions with Plicker cards. Counter to this, during focus group conversations, students commented that Plicker cards were easier to forget to take to class or lose within other writing equipment, compared to the clicker handset, due to the differences in the size and physical form of the two voting tools.

While voting times during clicker usage rely solely on student engagement and student response times, Plicker voting times have the additional reliance on the instructor’s camera efficiently capturing all QR code responses. Although this could be seen as a potential barrier to quickly obtaining cohort responses, this time difference appeared to be off-set somewhat by students typically answering quicker with the Plicker cards when compared to response times using the clicker handsets. This observation, though anecdotal, is understandable when considering that the Plicker platform leads to a visual show of who has and hasn’t voted in the class, by way of who is and isn’t holding up their Plicker card. It is conceivable that this typically led to the more self-conscious students rushing to vote so as not to appear slower in answering alongside their peers, which was reinforced verbally by some students during end of session conversations. Such informal student feedback may also address why 91.36% (N=81) favored clickers, when asked directly to choose between the two voting platforms, with 7.41% having no preference (see table 1).

The reduced privacy attached to Plicker voting may also explain why clickers received far more favorable feedback. However, while students may see the speed at which their peers vote based on how quickly the Plicker cards are held up, it is important to stress that the “A”, “B”, “C” and “D” text on the QR code is sufficiently small such that it would be impossible for a student’s individual answer to be visible to others in the class. In short, both polling platforms allowed individual student responses to remain confidential during and after polling.

From the two student focus group discussions this latter point appears to have been somewhat misunderstood. Students commented how many in the class believed that all Plicker cards were displaying exactly the same QR code, leading to students focusing on attempts to match the orientation of their QR code pattern to those held up by their colleagues, which students said was distracting and resulted in a loss of focus. In classrooms with parallel seating arrangements, students described how it was possible to see the shape of QR codes on Plicker cards that were held up in front of them, due to projector lighting producing a QR code silhouette through the back of the Plicker card. When it was explained in the focus groups that all cards were different, the students appeared surprised as many had not understood this key point, with some even believing that the role of the instructor’s tablet device was simply to photograph students voting, rather than capturing the votes in real-time for the Plicker software.

In summary, despite both voting approaches being explained to the students at the very start of the year, the focus group discussions highlighted that these initial instructions had not been completely understood and taken on board. Since clicker usage can reasonably be considered to be more self-explanatory, this may provide the clearest explanation of students’ preference for this voting platform. This was reinforced by one student who commented that it took at least two teaching sessions with Plickers before it became completely clear how to use them correctly, while also appreciating their actual purpose within the teaching session. So, a more comprehensive introduction to Plickers would appear to be required, compared to clickers, to avoid Plicker card confusion and misuse. Students also described how Plickers made it more obvious to their peers if they wished to opt out of voting or if they decided to change their answer, with the latter also leading to concerns that any changes might not be detected as readily with Plicker cards as when performing the same task using clickers.

Throughout all student discussions, the most common comment in relation to Plickers remained the need for more extensive instructions and practice when using them for the first time. Since both focus groups occurred after students had also used a team-based clicker approach it is noteworthy that students thought the Plicker card platform may better align itself with team voting as opposed to individual student voting; so, using one Plicker card per team of four. This team-based voting model was not evaluated as part of this particular work, however, its use through the clicker platform was favored by 94% of students over individual clicker usage in previous work by the author.9 Students also fed back how any confusion on use or privacy, when using Plickers, would be overcome with a team-based model. This latter suggestion is interesting since with a limit of 63 Plicker card combinations, the team approach would clearly expand the use of Plicker cards to much larger cohorts than is possible with an individual student voting strategy. Such an approach is therefore worthy of further study as this would have the added benefit of encouraging greater peer instruction, as has already been illustrated when using the clicker platform in this way.9,10

Concluding RemARKS

In-class voting with clickers continues to receive excellent student and instructor feedback when considerately inserted within PBL sessions, with such active learning aided greatly by the self-explanatory nature of clicker handset usage. In contract, student feedback was disappointing when employing Plicker voting cards, which clearly require greater instructor guidance when first introduced to students, however, this low-budget voting platform was still able to generate polling data in teaching environments where smartphones and other personal devices, including clicker handsets, may be prohibited or impractical to use. Furthermore, both Plickers and clickers gave satisfactory student compliance data during MCQ polls although clickers were able to service a broader range of class sizes and a greater variety of MCQ formats. In summary, both clickers and Plickers provided rapid, representative class polling data during PBL sessions whilst maintaining a smartphone-free teaching environment.

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