

Clickers in the Classroom: A Comparison of Interactive Student-Response Keypad Systems

[WORKING DRAFT]

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Abstract: This paper is addressed to the college or university faculty member contemplating adoption of an evolving form of classroom technology – the interactive student-response system (SRS). Marketed under a variety of brand names, this student-polling technology is designed to maximize student participation, especially in large-enrollment lectures. This paper looks at the components and operation of the two most common types of student-response systems, wireless keypad and Web-based input devices. Also provided is a brief survey of four decades of published research assessing the generally positive impact of student-response systems on teaching and learning.

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Disclaimer: the author is not affiliated with and has no financial interest in any SRS manufacturer or distributor.

Introduction

Student-response Systems (SRS)¹ are an evolving in-class-student-polling technology designed to create an engaging and inviting learning environment that will maximize active learning, especially in large-enrollment lectures. This technology has been used in higher education since the 1960s. (Judson and Sawada) Ward *et al.* divide the evolution of SRS technology into three generations: early homemade and commercial versions that were hard-wired into classrooms (1960s & 70s), 2nd generation wireless versions that incorporated infrared and radio-frequency wireless keypads (1980s - present), and 3rd generation Web-based systems (1990s – present). Earlier systems were originally designed for traditional, face-to-face courses; more recently some of the brands are adaptable to online courses as well, using WebCt, Blackboard, etc. Before higher education became interested, audience- or group-response systems were first developed for use in business (focus groups, employee training, and conference meetings) and government (electronic vote tabulation and display in legislatures and military training).

The operation of student-response systems is a simple three-step process: 1) during class discussion or lecture, the instructor displays² or verbalizes a question or problem³ – previously

¹ Unfortunately, there appears to be no standardization of terminology in the literature; student-polling systems are variously described by vendors and academic users as: audience-paced feedback systems (APF), classroom performance systems (CPS), electronic response systems (ERS), hyper-active teaching technology (H-ITT), interactive engagement (IE), interactive audience response systems (IRIS), interactive learning systems (ILS), interactive student-response systems (ISRS), personal response systems (PRS), group response systems (GRS), and wireless response systems (WRS). We will use the SRS acronym in this paper.

² The question or problem is typically displayed using a classroom projection screen; however, some newer student-response systems can display prompts on the video screen of each student's input device ("smart" keypads with LCD displays, PDAs, text-messaging cell phones, notebook or laptop computers).

³ Depending on the SRS system, question/response types may include: 1) the simple true/false, yes/no, or multiple-choice formats or 2) the more powerful formats of mean numeric entry, correct numeric entry, multiple-choice with multiple correct responses, rating scale 1-n, sequencing, or even short answer and fill-in-the-blank.

prepared or spontaneously generated “on the fly” by the instructor or a student,⁴ 2) all students key in their answers using wireless handheld keypads or Web-based input devices, 3) responses are received, aggregated, and displayed on both the instructor’s computer monitor and an overhead-projector screen. The distribution of student responses may prompt the students or instructor to explore further with discussion or perhaps one or more follow-up questions.⁵ This interactive cycle can continue until both the instructor and the students have resolved ambiguities or reached closure on the topic at hand.

SRS Potential Benefits

Student-response systems can benefit faculty in all three areas of responsibility: teaching, research, and service. The most commonly stated goal of student-response systems is to **improve student learning** in the following areas: 1) improved class attendance and preparation, 2) clearer comprehension, 3) more active participation during class, 4) increased peer or collaborative learning,⁶ 5) better learning and enrollment retention, 6) and greater student satisfaction.⁷

A second basic goal of all student-response systems is to **improve teaching effectiveness** in at least two ways. With student-response systems, immediate feedback is easily available from all students (not just the few extroverts in the class) on the pace, content, interest, and comprehension of the lecture or discussion. This timely feedback allows the instructor to better judge whether and

⁴ Some two-way student input devices allow any student to anonymously type in a question, comment, or answer for transmission to the teacher.

⁵ For example, many SRS programs allow student responses to be quickly cross-tabulated by demographics or responses to previous questions.

⁶ At least one system’s software, *Classtalk*, gives options for paired or small-group answers – even a group response with dissent – thereby building community in the classroom where students become active participants in salient discussions rather than passive recipients of lecture content and are empowered to influence the pace and direction of their instruction. (Dufresne, R.J. *et al.*, p. 11)

⁷ Some systems let you add interactive game questions to stimulate student focus and enhance peer interaction. One example is Option Technology’s *Jeopardy*-like game described at http://www.optiontechnologies.com/products/group_competition.asp.

how to amplify, clarify, or review. In addition, the instructor can also easily collect data on student demographics, attitudes, or behaviors to better assess the group characteristics of student needs.

A third goal of student-response systems is to greatly **reduce the paperwork and faculty labor** associated with: 1) attendance taking, 2) test administration,⁸ and 3) grade recording, calculation, and analysis. SRS operating system software typically automates data collection and report writing in a user-friendly fashion. In addition, most systems output data files to the standard database, spreadsheet, and statistical analysis packages.

A fourth (and not commonly emphasized) utility of all student-response systems is to provide a high-quality vote-tally system for: 1) campus meetings or workshops involving students, faculty, and/or staff and 2) town-hall style meetings in the community.⁹ Since many of the SRS packages are lightweight, transportable, and wireless, remote setups are relatively easy.

SRS Components and System Types¹⁰

Most student-response systems incorporate three basic components: 1) student input devices, 2) operating system software on the instructor's classroom computer, and 3) a classroom overhead projection system to display the questions asked and the distribution of student responses.

1) **Student input devices**: These devices fall into two types:

- a) Inexpensive **keypads** (one-way transmitters or two-way transmitter/receivers) with unique IDs to match specific students with their responses. All wireless keypad devices require

⁸ Some systems – e.g., *JoinIn on TurningPoint* – allow for self-paced testing, multiple tests, or multiple versions of the same tests. eInstruction's CPS has a Student Managed Mode that allows the instructor to distribute printed quizzes to the students who then respond at their own pace.

⁹ An interesting discussion of SRS use in town hall meetings is presented at:
<http://www.turningtechnologies.com/government.htm>

¹⁰ See Table 1 for a comparison of features offered by selected student response systems.

one or more IR or RF receivers to capture the students' signals.¹¹ The keypads and their matching receivers may be either:

i) Infrared (IR) keypads -- think TV remote with a limited set of response keys. Most IR keypads are one-way devices (which means that the student can only verify that their answer has been tallied by looking at a keypad number display projected on the classroom overhead screen).

ii) Radio frequency (RF) keypads -- most RF keypads are two-way devices (therefore the student keypad can flash a signal that verifies to the student that their answer has been received), which is ideal for graded work or recording required-attendance. Most RF keypads have alphanumeric keypads suitable for questions requiring numeric answers. Newer RF keypads include LCD screens that allow the student to see the question or problem text and their answer choice(s).

b) More expensive and sophisticated two-way **Web-based computer devices** constitute the second class of student input devices. These devices can take many forms – PDAs, smart calculators,¹² text-messaging cell phones, or pocket/notebook/laptop/desktop personal computers.

2) Software¹³ for either SRS keypad or Web-based devices¹⁴ falls into two types:

a) **Operating system software** that has two functions to perform:

¹¹ Keypad receivers are typically linked by standard network cabling to the serial or USB port on the instructor's computer. Newer keypad receivers may use a wireless link to the instructor's computer.

¹² The Texas Instrument's TI-Navigator™ Classroom Learning System is one example.

¹³ Most SRS software is written for PC operating systems, but some offer Macintosh versions, and some PC versions can run on Macs equipped with PC-emulator software.

¹⁴ Three currently available Web-based systems are: eInstruction's *vPad SRS*, Turning Technologies' *TurningPoint*, and UNC Wilmington's *Project Numina II SRS*.

- i) **Interactive activities during class:** to generate prepared or spontaneous questions (often with graphics and equations) in lectures, and to tally and display student responses.
 - ii) **Class management activities after class:** to record attendance and graded-question responses, which are typically downloadable to spreadsheet and statistics programs, and to post grades, results, and feedback online.
- b) Textbook-specific content software** (e.g., JoinIn™ on TurningPoint™) that gives the faculty member ready-made chapter outlines, case studies, graphic images, tables and figures, video clips, animations, quiz and test question-banks, and polling questionnaires.
- 3) A classroom projection system** (to display questions and/or response distributions) is required for most systems (the exception is found in “smart” RF keypad and Web-based systems where the student devices have screens that can receive both questions and response-displays.)

Table 1: A Comparison of Selected Student-response Systems

	eInstruction CPS	Hyper-Interactive Teaching Technology H-ITT	GTCO CalComp InterWrite PRS	Qwizdom Interact	Turning Technologies TurningPoint
Contact information	einstruction.com (888) 707-6819	h-itt.com (479)-582-2414	gtco.com (800) 344-4723 (800) 856-0732	qwizdom.com (800) 347-3050	turningtechnologies.com (866) 746-3015
Input device type compatibility	CPS	H-ITT	PRS	Qwizdom	Also compatible with CPS, H-ITT, & PRS
Wireless student keypad					
IR (one-way)	•		•		•
IR (two-way)		•		•	•
RF (two-way)	•		•		•
RF (two-way) with LCD			• (2-line LCD)	• (2 or 4-line LCD)	•
Wireless instructor keypad				• (4-line LCD)	
Web-enhanced device	•				•
Operating system compatibility					
MS-Windows	•	•	•	•	•
Macintosh	•	•	•	•	
Linux		•			
Technical support					
Toll-free phone	•		•	•	•
Phone	•	•	•	•	•
E-mail	•	•	•	•	•
Web	•	•	•	•	•
Textbook partnership	McGraw-Hill	Pearson (Addison/Wesley Benjamin Cummings Allyn & Bacon Longman Prentice Hall)	Pearson (Addison/Wesley Benjamin Cummings Allyn & Bacon Longman Prentice Hall) Houghton Mifflin Wiley & Sons	Pearson (Addison/Wesley Benjamin Cummings Allyn & Bacon Longman Prentice Hall) Houghton Mifflin Wiley & Sons	Thompson

SRS Outcomes Assessment

Across the past four decades there has appeared a small but growing literature that evaluates the effectiveness of various types of student-response systems. The findings have been mixed: less positive prior to the 1980s, more positive since. Regardless of time period, most of the reviews were quite limited – covering short time spans with relatively few students, reporting impressionistic or anecdotal findings,¹⁵ typically reviewing only one SRS brand, and largely restricted to SRS applications in math and science classrooms. Nevertheless, it is worthwhile to survey this literature in order to view SRS users' first-hand accounts of the impact of this technology on the following six areas of student learning:

- **Attendance and preparation:** Burnstein and Lederman found that, "... when keypad scores count for greater than 15% of the term grade, there is a dramatic improvement in attendance that reaches the 80-90% level and, in addition, the students make genuine attempts to prepare for the reading quizzes and remain alert throughout the lecture period." (2001, p. 8) Other researchers reported similar results attributable to more positive stimuli: classes are more interesting and lively with SRS, and students report more ownership of the pace and direction of class lecture and discussion. (Woods and Chiu, 2003, p. 3)
- **Comprehension:** Poulis et al. report that: "The mean pass rate ... of the APF (audience paced feedback) lectures is significantly higher than that where conventional methods have been employed. Of equal importance is the reduction in the standard deviation of this average, indicating a more consistent level of comprehension throughout any given class, and year by

¹⁵ A notable exception is Hake's rigorous statistical analysis of differences in pre/post test gains between 14 traditional and 48 interactive-engagement introductory physics courses enrolling over 6500 students in high schools, colleges, and universities.

year. (1998, p. 441) This finding is qualified somewhat by Slain *et al.*, who note: "... significantly higher scores were seen with ISR [interactive student response] use for those questions that required "analytical" type thinking consistent with Bloom's taxonomy of questioning The examination grades were not significantly different for questions that required strict memorization. (2004, p. 4)

- **Active participation during class:** Birdsall reports: "Obtaining this kind of feedback and student participation in large classes is largely impossible without this kind of system. Even in small classes, which can be made highly interactive without technology, this type of system ensures that all the students think through questions, without leaving it to the vocal minority." (2002, p. 2) Even in small-enrollment classes, many students are reluctant to respond to faculty questions; the anonymity of responding with a hand-held device guarantees near or total participation by the entire class. (Ward, et al., p. 3) Burnstein and Lederman advise: "It is valuable to use keypads in an anonymous mode. In some systems an anonymous response mode is [an option] built into the software. In other systems this can be accomplished by having the students temporarily trade keypads." (2003, p. 274)
- **Peer or collaborative learning:** David Lowe reports that, "I think the interactive methods are great for getting students started in thinking through the material, as well as getting them talking to each other about the material, which often leads to discussions that continue outside class. For example, I think these methods increased the number of students who got together in informal study groups." (as quoted in Birdsall, 2002, p. 3) A commonly recommended strategy is to allow students to confer before submitting their answers. (Mazur, 1997) Students can be encouraged to defend or explain their answers promoting further student discussion "... that advances understanding of concepts and unveils misconceptions ..." (Judson and Sawada, p. 177) "If most of the class answers a question correctly, the students answering incorrectly may

be motivated to read or think more deeply about the subject matter.” (Woods and Chiu, p. 2)

Steve Ehrmann reports that, “I’ve noticed that some faculty use student-response systems to pose conceptually challenging questions. They display the results, use them to provoke small group debate as students attempt to persuade their peers to their point of view, and then poll the class again. This is an educationally powerful thing to do, with documented gains in learning.” (as quoted in Frey and Wilson, 2004, “Student-response Systems”)

- **Learning and Enrollment Retention:** “Daily use of [SRS] questions gives students repeated exposure to ... and emphasizes the concepts and ideas that the instructor thinks most important.” (Woods and Chiu, p. 2) Cordes offers a further advantage: “Institutions can systemically address issues of concern to the campus as a whole. For example, student retention and success have been positively correlated to class attendance. Providing an infrastructure that promotes these activities in large classes is essential, as it is these classes that impact the greatest number of students—often early in the student’s academic career.” (2001, p. 10)
- 3) **Student satisfaction:** In a review of four decades of literature, Judson and Sawada conclude that, “Students have always favored the use of electronic response systems and attribute such factors as attentiveness and personal understanding to using electronic response systems.” (p. 167) Judson and Sawada also conclude: “Polls from the 1960s through the late 1990s found that the use of electronic response systems made students more likely to attend class, pressed them to think more, promoted them to listen more intently, and made them feel instructors know more about them as students.” (2002, p. 177)

Factors to Consider in SRS Purchase Decisions

Making choices between student-response systems is challenging because there are many different manufacturers, products, options, and pricing arrangements. Keep in mind the following considerations when contemplating the purchase of a student-response system.

IR Keypad Systems:

These systems offer the least expensive transmitters and receiver(s). Students will be happy that campus bookstores will often buy back student keypads at the end of the term. However, IR keypad systems have a number of disadvantages. IR keypads have the least dependable signal reception of all other types of student input devices (a significant problem for high-stakes required-attendance taking and grading). IR keypads require unobstructed line-of-sight aiming by students within a specified viewing angle and have a relatively short range (~ 80 ft. or less). As the keypad/receiver ratio increases, IR signal interference also increases. The ratio of keypads to receiver varies by manufacturer but generally is between 40:1 and 80:1. Permanent installation of receiver(s) in the classroom can be costly depending on the number of receivers required and building code requirements for conduit. All but one IR keypad are one-way systems that require the student to verify the reception of their responses by checking a display on the projection screen at the front of the room.¹⁶ This requirement is sometimes problematic – especially in large-enrollment classes. Both the signal-reception and visual-verification shortcomings decrease the utility of IR keypad systems for recording required attendance or graded work, since student perceptions of system reliability is critical for such applications. Finally, IR keypad systems are receiver specific – you can't mix keypad types or brands.

RF Keypad Systems:

¹⁶ The sole exception so far seems to be H-ITT's new two-way IR keypad.

These systems are more costly than IR keypad systems; however, they are considerably less expensive than Web-based systems (unless all students are otherwise required to have PDAs or pocket/notebook/laptop PCs). Like IR keypads, campus bookstores will often buy back student RF keypads at the end of the term. Compared to IR systems, RF systems have a higher ratio of keypads to receivers (100+:1). Compared to IR systems, RF systems have much more dependable signal reception (RF keypads do not require line-of-sight aiming by students (they can be left flat on the desk top) and have a longer range ~100-200 ft.). Several manufacturers are now offering two-way RF keypad systems that allow the student to verify the reception of their responses on their keypads without checking a display on the screen at the front of the room.

Some RF keypad systems share some of the drawbacks of IR systems. Unless they are wireless, permanent installation of RF receiver(s) in the classroom can be costly depending on number of receivers required and code requirements for conduit. RF keypad systems are receiver specific – you can't mix keypad types or brands.¹⁷ In addition, there is also some potential for interference from other RF sources.

Web-based Student-response Systems:

Some Web-based systems¹⁸ allow different students to use more than one input device in the same classroom (e.g., some students may use pocket/notebook/laptop computers, other students may use PDAs, and still others may use text-messaging cell phones). Many institutions already have campus-wide or building wireless networks, so no additional wiring or conduit installation costs are necessary (an especially important consideration in large lecture halls). Web-based systems offer far more powerful student input devices than either IR or RF keypad systems. Web-

¹⁷ There is a new SRS software option, Turning Technology's TurningPoint software, that will work with most student input devices, whether IR keypad, RF keypad, or Web-based input devices.

¹⁸ Two examples of Web-based systems are UNC Wilmington's *Project Numina II SRS* and eInstruction's *vPad CPS*.

based systems do not require a classroom projector and screen – questions and/or images can be transmitted directly to each student’s cell phone, PDA, or pocket/notebook/laptop PC, hence there can be less straining by students to read a distant screen at the front of the classroom. Like many two-way RF keypads, the two-way Web-based input devices allow each student to verify reception of their responses. Like RF keypads, Web-based input devices probably have fewer contention or signal-reception problems than IR keypad systems.

However, Web-based systems do have drawbacks. Compared to both IR and RF keypads, Web-based input devices are considerably more expensive. Also, Web-based student-response system development lags IR and RF keypad system development – there are not as many choices of products or textbook bundling options. Finally, with the more powerful Web-based input devices there is opportunity for off-task behavior (Web-surfing, reading e-mail, etc.)¹⁹ or student dishonesty via crib notes, Internet access, text messaging, etc.²⁰

¹⁹ Ward *et al.* report a study of off-task behavior during SRS sessions using Web-enabled PDAs finding 10-20% of lab students were observed to be off task at some point during 25-minute labs.

²⁰ Although more limited, there is still opportunity for cheating to occur with one-way keypad systems, e.g., dishonest students might give their keypads to other students for attendance or graded work.

General Considerations:

Student-response hardware, software, and textbook bundling options are rapidly evolving. Purchasers and adopters are faced with keeping track of multiple variables. However, costs are coming down and new or improved features are constantly appearing. Hence, it seems prudent to: 1) limit commitments to small-scale investments, and 2) not settle too quickly on department, college, or campus-wide standardization. On the other hand, there may be significant compatibility or support issues when different SRS products are installed in the same classroom or when students are asked to purchase and carry around competing keypads or other input devices.

While student-response systems are easy to use by students, they come with not-insignificant learning curves for faculty members. Like other educational technology (WebCT comes to mind), it is a good idea to start simple the first semester or two and slowly ramp up to using more complicated options. If wiring or conduit installation is necessary, schedule that well in advance of the beginning of the school term. Network with IT support personnel and faculty on your campus who have experience with a student-response system – even if it is not the one you have chosen. They often can warn you of unexpected pitfalls and you may avoid “reinventing the wheel” experiences. Make sure that your student-response system complies with student privacy regulations on your campus as laid out in the Family Educational Rights and Privacy Act (FERPA) posted at: <http://www.ed.gov/policy/gen/guid/fpco/ferpa/index.html>. For example, if the vendor collects any student data, find out whether it is shared or sold to others.

Determine whether and how your SRS software handshakes with other software. Can it import or export from/to Microsoft Office Suite components (Word, Excel, Access, Outlook, and PowerPoint), statistical analysis software (SPSS, SAS), grade-book programs, and multimedia (audio/video) files?

Besides those technological issues, you will want to give serious attention to pedagogical issues as well. A useful place to start may be a teaching-with-technology resource center on your campus. They may offer workshops, Web-based tutorials, or handouts.²¹ In any case, you should provide very clear instructions to first-time student users in handouts or on your course web site. Practice using your new student-response system at least once before your maiden voyage in the classroom with students. If a convenient option, you may decide to switch from 50-minute to 75-minute class periods in order to have more time to devote to interactive student-polling activities. Student-response technology is a potentially useful teaching and learning tool that students enjoy using, but one that will only be beneficial to the extent that faculty craft useful questions and facilitate student discussions in order to foster an active learning environment.

²¹ A good example of a brief primer for SRS users can be found at the Center for Education Research and Evaluation web site:
http://library.cpmc.columbia.edu/cere/web/facultyDev/ARS_handout_2004_tipsheet.pdf

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Appendix: Vendor Website Directory

1. Classtalk Classroom Communication System (CCS)
<http://www.bedu.com/classtalk.html>
2. ClassAct Student Response System (SRS)
<http://www.ljgroup.com/products/classactsrs/>
3. eInstruction Classroom Performance System (CPS)
<http://www.einstruction.com>

McGraw-Hill/eInstruction CPS
<http://www.mhhe.com/cps/>
4. Fleetwood Reply Wireless Response Systems (WRS)
<http://www.replysystems.com/>

Meridia Audience Response System (ARS)
<http://www.meridiaars.com/appeduc.htm>
5. Hyper-Active Teaching Technology (H-ITT)
www.h-itt.com

Pearson/H-ITT
<http://www.aw-bc.com/h-itt/>
6. GTCO-Cal Comp, InterWrite Personal Response System (PRS) [formerly EduCue]
<http://www.gtcocalcomp.com/interwriteprs.htm>

Pearson/InterWrite PRS
<http://www.aw-bc.com/prs/index.html>
7. Option Technologies' Interactive Option Finder VP
<http://www.optiontechnologies.com/products/ofvp.asp>
8. Quizdom Interact
<http://qwizdom.com/>

9. Texas Instrument's TI-Navigator
<http://education.ti.com/us/product/tech/navigator/features/features.html>

10. TurningPoint System
<http://www.turningtechnologies.com/highereducation.htm>
Thompson/Wadsworth's JoinIn on TurningPoint
http://www.wadsworthmedia.com/TurningPoint/TurningPoint_Demo.html

11. UNC Wilmington, Project *Numina II* Student Response System (SRS)
<http://aa.uncwil.edu/numina/>