How to improve student learning in every classroom now

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A B S T R A C T

This paper is our attempt to help any of the world's 60 million teachers who ask, "What can I do right now to improve learning in my classroom?" We describe three easy-to-use teaching tactics derived from applied behavior analysis that consistently yield measurably superior learning outcomes. Each tactic is applicable across curriculum content and students' age and skill levels. Considerations for using digital tools to support and extend these "low-tech" tactics are also discussed.

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1. Introduction

Education is fundamental to all other human rights (Committee on Economic, Social and Cultural Rights, 1999; UNESCO, 2016). As noted by Lee, "[I]f children receive basic primary education, they will likely be literate and numerate and will have the basic social and life skills necessary to secure a job, to be an active member of a peaceful community, and to have a fulfilling life" (Lee, 2013; p. 1). Yet many children worldwide, rich and poor fail to receive even a basic primary education. Overcrowded classrooms, untested and ineffective curricula, and inadequately prepared or underpaid teachers are often to blame. Absence of the most basic instructional materials such as textbooks and chalkboards is a barrier in the poorest countries (Hillman & Jenkner, 2004). Simply spending money on education is not the answer. Countries that spend billons on school-reform "solutions" also struggle to educate all their students.

Although school reform is a complex problem warranting large-scale, systems-based solutions, individual teachers can make a tremendous difference in student learning by focusing on *alterable* variables. Alterable variables are factors that both impact student learning and can be controlled by teaching practices (Bloom, 1980). Alterable variables include critical dimensions of curriculum and instruction such as the amount of time allocated for instruction; the selection and sequence of content examples and non-examples; the type and sequence activities within a lesson; the pace of instruction; the frequency and type of student response (e.g., recognition or recall) with which students actively participate during instruction; how and when teachers provide praise or other forms of reinforcement; and how errors are corrected.

Applied behavior analysis (ABA) provides a scientific approach to designing, implementing, and evaluating instruction based on empirically verified principles describing functional relationships between events in the environment (e.g., what the teacher does) and desired behavior change (e.g., student learning) (Baer, Wolf, & Risley, 1968; Baer, Wolf, & Risley, 1987;

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Cooper, Heron, & Heward, 2007). Research by applied behavior analysts has helped identify alterable variables and developed many classroom-tested teaching strategies and tactics focusing on those variables (Chance, 2008; Embry & Biglan, 2008; Greer, 2002; Heward et al., 2005; Twyman, 2014a; Vargas, 2013). The most robust of these practices—those that consistently yield measurably superior student learning outcomes for learners of all ages and performance levels—share a common framework: sound instructional design (Markle, 1983/ 1990; Twyman, Layng, Stikeleather, & Hobbins, 2005), high rates of relevant learner responses with contingent feedback (Hattie & Timperly, 2007; Heward, 1994), and ongoing instructional decision-making based on direct and frequent measures of student performance (Bushell & Baer, 1994; Greenwood & Maheady, 1997).

We describe three teaching tactics derived from or refined by ABA that embody or make transparent each of these fundamental elements; tactics with which teachers in any classroom, rich or poor, can tackle a common problem.

2. Low-tech solutions to a universal problem

Group instruction is the global norm (see Fig. 1) and the most common teaching arrangement regardless of grade level (Hollo & Hirn, 2015). Instructing more than one student, be it an entire class or a small group, presents five simultaneous challenges: maintain students' attention, give each student sufficient opportunities to respond, provide individualized feedback for students' responses, monitor each students' learning, and prevent and deal with disruptive behavior. Meeting these challenges is so demanding that when students simply pay attention (e.g., look at the teacher, the board, or lesson materials; watch a peer respond) and do not misbehave, it is taken as evidence of a successful lesson.

Students, and teachers, deserve more. We describe three research-based tactics—choral responding, response cards, and guided notes—that increase active student responding (ASR; Heward, 1994) and help teachers meet all five challenges of group instruction. When properly implemented, each tactic enables all students in the class to respond frequently throughout the lesson, incorporates feedback to students, gives the teacher ongoing assessment of students' understanding of the lesson, encourages on-task behavior, and promotes learning.

In addition to its strong research support, each tactic is a "low-tech" application that can be used in any classroom. Low-tech solutions are cost-free or entail only nominal expenditure for materials (e.g., pencils, paper, notecards, file folders), require no hardware or batteries, need no maintenance or software to keep current, do not involve software or Internet/connection glitches, are easy and quick for teachers to learn, and can be implemented straight away in any classroom.
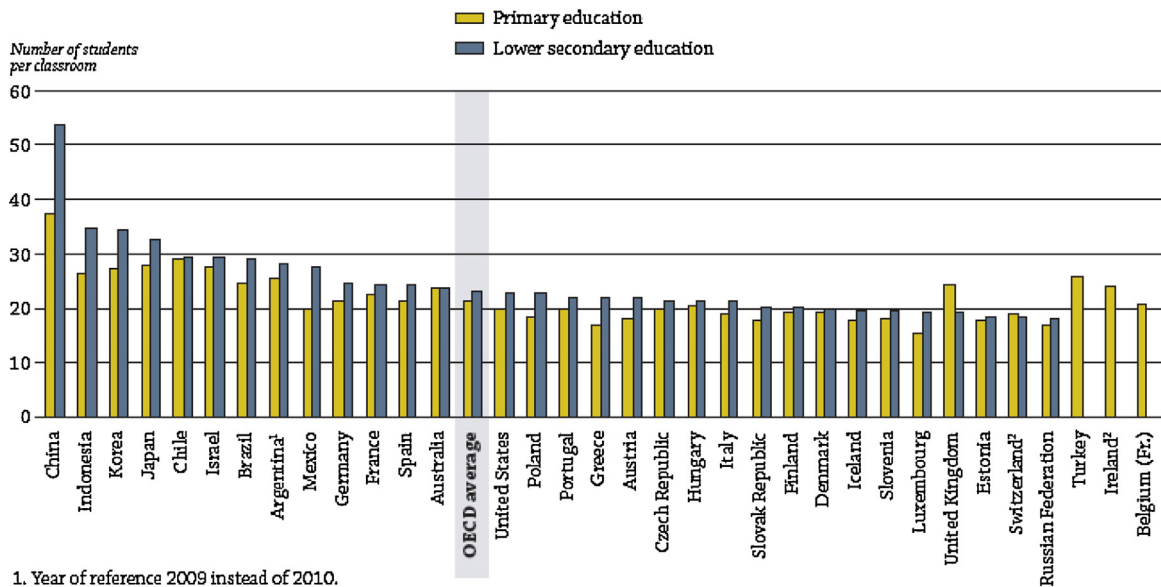
Fig. 1. Mean number of students per classroom in primary and lower secondary public schools by country.
Source: Organization for Economic Co-operation and Development (2012). "Education Indicators in Focus: How does class size vary around the world?" http://www.oecd.org/edu/skills-beyond-school/EDIF%202012–N9%20FINAL.pdf.

2.1. Choral responding

Choral responding—students responding orally in unison to a series of questions presented by the teacher—is the simplest, quickest way to increase student participation during group instruction. Choral responding (CR) an be used effectively with any curriculum content that meets three criteria: (a) each question, problem or item presented has only one correct answer; (b) each question can be answered with a brief oral response or verbal chain (e.g., counting by 5); and (c) the material can be presented at a lively pace. Teachers can use CR for lessons on basic academic tools skills, subject matter content, or a series or sequence of steps to solve higher-level problems (e.g., math word problems). CR can be used to prime students' background knowledge when introducing new content (Coyne, Kame'enui, & Carnine, 2011), interspersed in brief doses throughout a lesson, and provide a brief end-of-lesson review. CR can also improve transitions from one classroom activity or location while providing practice on academic and social skills (Connell, Randall, Wilson, Lutz, & Lamb, 1993; Johnson, 1990).

Peer-reviewed research reporting positive effects of CR on ASR, learning outcomes, and deportment has been published since the late 1970s (e.g., McKenzie & Henry, 1979; Pratton & Hales, 1986; Sindelar, Bursuck, & Halle, 1986; and see Haydon, Marsicano, & Scott, 2013). CR has been used successfully with students from preschool through secondary grades (Rose & Rose, 2001; Sainato et al., 1987), with general education students (Kretlow, Cooke, & Wood, 2012; Maheady, Michielli-Pendl, Mallette, & Harper, 2002), and with special education students with various disabilities (Alberto, Waugh, Fredrick, & Davis, 2013; Cihak, Alberto, Taber-Doughty, & Gama, 2006; Flores & Ganz, 2009; Sterling, Barbetta, Heward, & Heron, 1997).

The basic procedure and suggested guidelines for conducting choral responding are described in Fig. 2. To learn more about CR, see Heward and Wood (2015).

2.2. Response cards

Response cards (RCs) are cards, signs, or items that students hold up to display their answers to teacher-posed questions or problems. With *preprinted RCs*, students select the card with the answer of their choice (see Fig. 3). Examples include yes/true and no/false cards, colors, traffic signs, molecular structures, and parts of speech. A single RC with multiple answers printed on clearly marked sections can also be used, such as the "Parts of a Story" and multiple-choice cards shown in the photo.

> ➤ *Give Clear Directions and Model the Activity* – Tell students the type of question to be asked and act out the roles of teacher and students for one or two trials. For example: *"How many hydrogen atoms in a molecule of methane?"* [pause briefly, give signal for students to respond] *"Four."*
>
> ➤ *Provide a Brief Thinking Pause* – Let the complexity of the question/problem and students' relative level of mastery determine the duration of the pause. If a thinking pause greater than 4 or 5 seconds is required for students to answer, break the content into smaller chunks
>
> ➤ *Signal Students to Respond* – Use a clear, consistent auditory and/or visual signal for students to respond. For example, "Class," "How many?," a finger snap, or a hand or arm movement. Saying "Get ready" immediately before signaling the students' response promotes unison responding.
>
> ➤ *Provide Feedback* – When hearing only correct answers, confirm and/or praise and immediately present the next question. When one or two incorrect responses are heard, (a) confirm the majority response and restate the correct answer in context with the question (e.g., "Yes. Lithium is an akalai metal."), and (b) repeat the question a few trials later. When more than a few incorrect responses are heard, (a) state the correct answer with a *brief* explanation (e.g., "Remember lithium is the first of six alkali metals on the periodic table."), (b) immediately repeat the question for CR, and (c) present the same question again several trials later.
>
> ➤ *Intersperse Individual Turns* – Now and then, instead of signaling a CR, call on an individual student. Present the question before calling a randomly selected student's name so students cannot predict when they will be called on. Individual turns can also be used to give low-achieving students opportunities to shine in front of their classmates. After a low-achieving student chorally voices a correct response, the teacher repeats the question several trials later and calls on that student to answer individually.
>
> ➤ *Maintain a Lively Pace.* When teachers conduct CR at a fast pace, students make more responses, respond with higher accuracy, and engage in less off-task behavior when teachers conduct CR at a fast pace. Preparing questions and examples prior to the lesson enables the teacher to focus on students' responses and move without hesitation from one learning trial to the next.
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> *Source:* Adapted from W. L. Heward with S. R. Alber-Morgan, & M. Konrad. (2017). *Exceptional Children: An introduction to Special Education* (11th ed.) (p. 189). Upper Saddle River, NJ: Pearson.

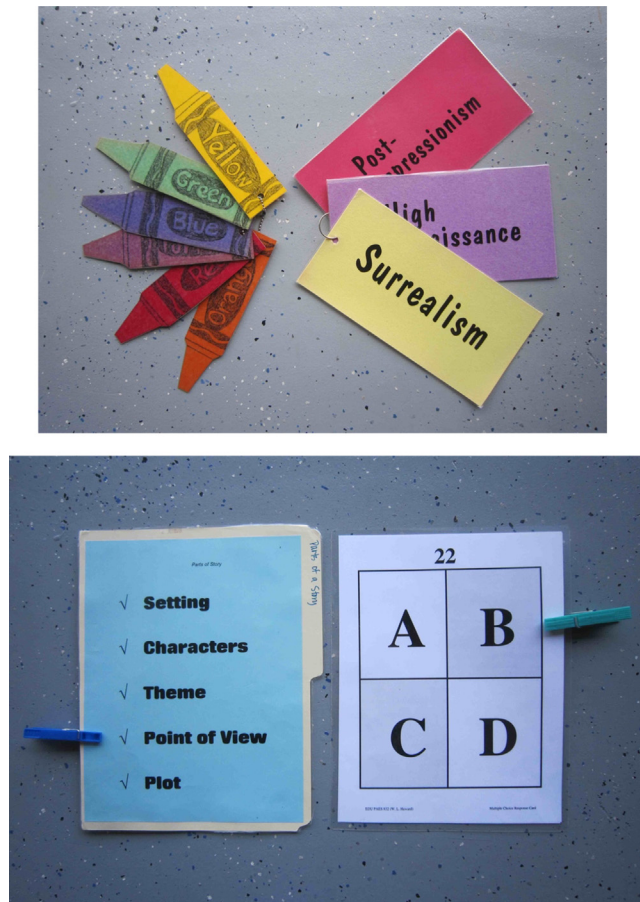**Fig. 2.** Guidelines and suggestions for choral responding.

Fig. 3. Teacher created response cards for lessons on various topics.
Source: photographs courtesy William L. Heward.

With *write-on RCs*, students mark their answers on blank cards that they erase between opportunities to respond. Write-on RCs can be custom made for specific curriculum content. For example, music students might mark notes on an RC on which the treble and bass clef scales are drawn in permanent marker; driver's education students could draw where their car should go on RCs with permanent streets and intersections.

Teachers can make a set of 40 durable write-on RCs from a 4-by-8-foot sheet of white laminated bathroom board (cheaply available from most builders' supply stores). Dry-erase markers are available at most office supply stores, and paper towels or scraps of cloth will easily wipe the RCs clean.

A study comparing write-on RCs with the teacher calling upon individual students to respond during whole-class science lessons in an inner-city fifth-grade classroom produced three major findings (Gardner, Heward, & Grossi, 1994). First, with RCs, each student responded to teacher-posed questions an average of 21.8 times per 30-min lesson, compared to a mean of 1.5 academic responses when the teacher called on individual students. The higher participation rate takes on major significance when its cumulative effect is calculated over the course of a 180-day school year. A teacher using RCs instead of HR for just 30 min per day, would enable each student in his or her class to make more than 5000 additional academic responses during the school year. Second, all 22 students scored higher on next-day quizzes and 2-week review tests that followed lessons with RCs than they did on quizzes and tests that followed lessons with HR. Third, all but one student preferred RCs over hand raising.

Numerous studies evaluating the effects of RCs with general and special education students at the elementary, middle, and secondary levels have produced a similar pattern of findings: increased active responding, higher scores on quizzes and exams, and students' preference RCs over business as usual (e.g., Cakiroglu, 2014; Cavanaugh, Heward, & Donelson, 1996; Horn, 2010; Skibo, Mims, & Spooner, 2011). In addition to increased participation and learning outcomes for students, several studies have found improved on-task behavior and decreases in the frequency of disruptions and inappropriate behavior when students used RCs (e.g., Duchaine, Green, & Jolivette, 2011; Lambert, Cartledge, Heward, & Lo, 2006; Wood, Mabry, Kretlow, Lo, & Galloway, 2009; Schwab, Tucci, & Jolivette, 2013).

Fig. 4 contains suggestions for using RC. To learn more about RC see Heward et al. (1996).

All Types of RCs

➢ Model several trials and have students practice using their RCs.

➢ Give clear cues when students are to hold up and put down their cards.

➢ Maintain a lively pace throughout the lesson; keep intervals between trials short.

➢ Students can learn from watching others; do not let them think it is cheating to look at classmates' RCs.

Preprinted RCs

➢ Design the cards to be as easy to see (e.g., consider size, print type, color codes).

➢ Make the cards easy for students to manipulate and display (e.g., put answers on both sides of the cards; attach a group of related cards to a ring; see photo).

➢ Begin instruction on new content with a small set of fact/concept cards (perhaps only two), gradually adding cards as students' skills improve.

Write-On RCs

➢ Limit language-based responses to one to three words.

➢ Keep a few extra markers on hand.

➢ Be sure students do not hesitate to respond because they are concerned about making spelling mistakes: (a) provide several practice trials with new terms before the lesson begins; (b) write new terms on the board, and tell students to refer to them during the lesson; and/or (c) use the "don't worry" technique: tell students to try their best but misspellings will not count against them.

➢ Students enjoy doodling on their RCs. After a good lesson, let students draw on them for a few minutes.

Source: Adapted from W. L. Heward with S. R. Alber-Morgan, & M. Konrad. (2017). *Exceptional Children: An introduction to Special Education* (11th ed.) (pp. 204-205). Upper Saddle River, NJ: Pearson.

Fig. 4. How to use response cards.

2.3. Guided notes

Note taking serves two functions: a *process function* (the note taker interacts with the curriculum content during the lecture by listening, looking, thinking, and writing) and a *product function* (the note taker produces a summary or outline of key points for later study) (Boyle, 2001). Effective note taking requires discriminating between relevant and irrelevant content and facts, attending to teachers' "verbal signposts," organizing information, and recording information accurately and fluently (Kiewra, 2002). These skills are noticeably lacking in the repertoires of many students and especially challenging for those with disabilities.

Guided notes (GN) are teacher-prepared handouts that "guide" a student through a lecture with standard cues and specific spaces in which to write key facts, concepts, and/or relationships (Heward, 2001). Guided notes help students succeed with both functions of note taking. With regard to the process function, guided notes take advantage of one of the most consistent and important findings in recent educational research: *Students who make frequent, relevant responses during a lesson (ASR) learn more than students who are passive observers.* To complete their GNs, students must respond throughout the lecture by listening, looking, thinking, and writing about the lesson's content. Guided notes assist students with the product function of note taking because they are designed so that all students can produce a standard and accurate set of lecture notes for study and review (see Fig. 5 for an example of guided notes for a lesson).

Numerous studies have found that students at all achievement levels in elementary through postsecondary classrooms perform better on tests of retention of lecture content when they used GNs than on tests based on lectures when they took their own notes (e.g., Austin, Lee, Thibeault, & Bailey, 2002; Hamilton, Seibert, Gardner, & Talbert-Johnson, 2000; Jimenez, Lo, & Saunders, 2014; Konrad, Joseph, & Eveleigh, 2009; Neef, McCord, & Ferreri, 2006; Patterson, 2005; Williams, Weil, & Porter, 2012).

In addition to requiring students to actively respond to curriculum, helping them produce an accurate set of notes, and improved retention of course content, other advantages of GNs include (Heward, 2001):
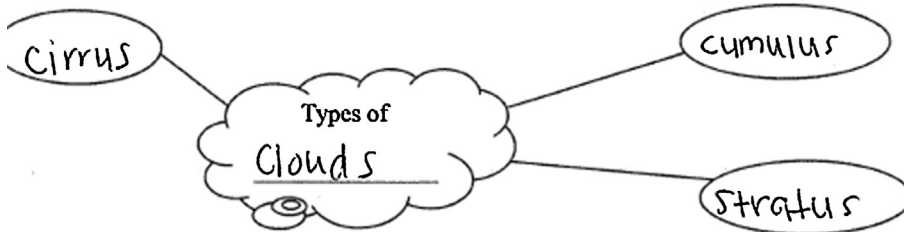
Clouds

Directions: Follow along with your teacher and fill in your guided notes.

What Are Clouds?

★ Clouds are tiny drops of condensing ___Water vapor___ or ___Ice crystals___ that settle on particles of dust in the atmosphere.
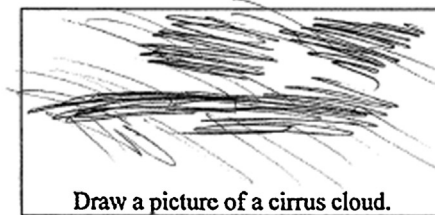
What Are the Different Kinds of Clouds?

★ Although there are many different types of clouds, there are ___three___ main types:

How Do I Know What Type of Clouds Are in the Sky?

- Cirrus clouds
  - Most common
  - Usually made of ___Ice crystals___
  - Look like feathers
  - Thin and ___wispy___

Draw a picture of a cirrus cloud.

- Cumulus clouds
  - White and ___puffy___
  - Look like cotton balls
  - Usually predict ___fair weather___ but can develop into ___cumulonimbus clouds___, which may produce rain, lightning, strong winds, and hail
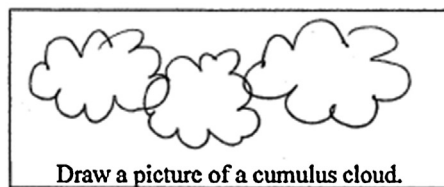

Draw a picture of a cumulus cloud.

Fig. 5. Example of guided notes for an elementary lesson on clouds.
Source: courtesy Moira Konrad, The Ohio State University.

- *Students can easily identify the most important information.* Because GNs cue the location and number of key concepts, facts, and/or relationships, students can better determine if they are "getting it" and are more likely to ask the teacher to clarify. Teachers often report that students ask more content-specific questions during lectures when GNs are used.
- *Teachers must prepare the lesson or lecture carefully.* This prompts them to think about and plan for covering the learning objectives and main points, and how to arrange the material for optimal learning.

- *Teachers are more likely to stay on-task with the lecture's content and sequence.* Teachers, especially those who are most knowledgeable and interested in their subject matter, get side-tracked from main points students need to know. While these tangential points may be interesting, they make it difficult for even skilled note takers to determine what's most important in a lecture/demonstration.
- *GNs can improve students' independent note-taking skills.* Gradually fading the use of GNs can help students learn to take notes in classes in which GNs are not used (White, 1991). For example, after several weeks of providing students with GNs for the entire lecture, the teacher might give GNs for only three quarters of the lecture, then one half of the lecture, and so on.

Fig. 6 contains suggestions for creating and using guided notes. For more details on these and additional suggestions for developing and using guided notes, see Heward (2001) and Konrad, Joseph, and Itoi (2011).

3. Using "high-tech" to ramp up learning

Low tech strategies are affordable, doable, and effective across classrooms. But what about 21st Century "connected" classrooms? Do the same fundamentals regarding high rates of relevant active student responding, feedback, and ongoing

1. *Examine existing lecture outlines to identify the most important course content that students must learn and retain via lectures.* Remember: less can be more. Student learning is enhanced by lectures with fewer points supported by additional examples and opportunities for students to respond to questions or scenarios.
2. *Include all facts, concepts, and relationships students are expected to learn on guided notes.*
3. **Include background information so that students' note taking focuses on the important facts, concepts, and relationships they need to learn.**
4. **Delete the key facts, concepts, and relationships from the lecture outline, leaving the remaining information to provide structure and context for students' note taking.**
5. **Insert cues such as asterisks, bullets, and blank lines to show students where, when, and how many facts or concepts to write and provide students with a legend that explains each symbol.**
6. **Leave ample space for students to write.** Providing three to four times the space needed to type the content will generally leave enough room for students' handwriting.
7. **Don't require students to write too much.** Using GNs should not unduly slow down the pace of the lesson.
8. **Enhance GNs with supporting information, resources, and additional opportunities to respond.** Insert diagrams, illustrations, photos, highlighted statements, or concepts that are particularly important, and resources such as websites into GNs. Interspersing sets of questions or practice problems within the GN gives students additional opportunities to respond and receive teacher feedback during the lesson. Guided notes can be designed so that students create a set of study cards for subsequent review and practice.
9. **Use PowerPoint slides or other visuals to project key content.** Visually projecting the key facts, definitions, concepts, and relationships enhances student access to the most critical content and improves the pace of the lecture.
10. **Intersperse opportunities for other forms of active student response during lesson.** Stop lecturing from time to time, and ask a series of questions, to which the students respond chorally or with response cards (see Chapter 2), referring to their GNs for answers as needed.
11. **Consider gradually fading the use of guided notes to help students learn to take notes in classes in which they are not used.**
12. **Provide follow-up activities to ensure that students study and review their notes,** such as daily quizzes, collaborative review activity, and random study checks.

Source: Adapted from Heward, W. L. (2013). *Exceptional children: An introduction to special education* (10th ed.) (pp. 184-186). Upper Saddle River, NJ: Pearson.

Fig. 6. Creating and using guided notes.

assessment of student learning apply? We propose that when founded on the same research based principles of behavior, "high tech" tools can also improve learning, thus the increasingly prevalent mobile and digital technologies powered by the capacity and reach of the Internet has the potential to enhance education at all levels (Twyman, 2014b).

It may be useful to first define what we mean by "technology." Typically technology is the use and knowledge of tools, techniques, systems or methods to solve a problem or serve some purpose (see Technology n.d). This definition refers not only to tangibles such as materials, tools, hardware, or software, but also to knowledge, processes, or strategies and tactics. The three easy to make, easy to use tactics featured earlier fit a definition of "low tech." However, we shall distinguish between two forms of technology described in the definition: the first refers to "things," and the latter to "behaviors" (Layng & Twyman, 2014; Twyman, 2014b). Further, the "things" of technology may be described as "low tech" (i.e., devised or made simply with common low cost resources, such as CR, RC, and GN) or "high tech" (i.e., utilizing more sophisticated resources and materials,[1] as we will cover below). The same may be said about technology of behavior change, or in our case, more specifically of instruction. Some instructional technologies may be "low tech" (i.e., extremely easy to implement with few barriers for use, again as found in CR, RC, and GN) or "high tech" (i.e., more complicated or requiring extensive training before implementation, which this paper does not cover). When applying instruction, it's not an "either or" proposition regarding the type (tools or behavior) or level (low or high) of technology used. Mixed applications, such as the using "high tech" tools to support "low tech" tactics, are not only possible, but also often desirable. This is what we will turn to next.

Continuing with our push to increase ASR (a low tech strategy) there are a number of digital devices and software applications (high tech tools) that promote high rates of meaningful learner responses. We now consider features of high tech tools that support the implementation of our three low-tech research-based tactics, covered in reverse order: guided notes, response cards, and choral responding. To make our examples clear, we refer to specific apps and tools. Citing an app by name and providing the url does not constitute an endorsement of the app nor indicate its availability; app examples were selected simply to illustrate the various features discussed in this article.

3.1. Guided notes

Keeping with the dual functions of guided notes (i.e., process function and the product function; Boyle, 2001) there are a number of high tech tools that learners can use to interact with the content and produce permanent products for later study. These can be as simple as "pushing" an electronic version of the teacher created GN page out to all students, who then complete the notes while on their computer, tablet, or smartphone, saving their work for later review. As GN require pre-planning and organization on the part of the teacher, applications are available to help teachers create them for electronic dissemination or printing. For example, "Guided-Notes Maker" (https://www.interventioncentral.org/rti2/guided_notes) is a website from Intervention Central enables teachers to quickly create guided notes by copying and pasting their own notes into a text box, then highlighting words or phases to blank them out. A button click turns the material into a PDF, which students can complete by hand or electronically. During lectures or class discussions, the GN may be displayed via overhead projector, computer projector, or electronic whiteboard to be completed as a group, or individually later.

Related is the "Handouts" app (http://handouts.in) that converts word documents and PDFs into digital pages on which students can write and draw. Teachers assign the "handout" to the whole class or selected students, students then complete them on their own and post their work for their teacher to review. Teachers can easily see who has completed the assignment, exactly what each student did, and electronically provide comments and feedback for students. Digital GN can easily be catalogued and shared, a benefit for teachers looking to "crowd source" and circulate teaching materials.

While most word processing programs support the modification of almost any electronic document into a GN, Google Forms (https://www.google.com/forms/about/) can be used to create GN that can be "self-grading," once a learner completes and saves them electronically.[2] Not only can the learner obtain feedback on the accuracy of his or her notes, but the teacher can also view an automatically created database of GN completions, accuracy, and even how often they are accessed online—supporting instructional decision-making.

Another Google application, Pear Deck, (https://www.peardeck.com) is formed from slides or a PDF of teacher created content and supports a variety of student response formats such as multiple choice questions, ratings, sliding scales, and freehand drawing or writing. Teachers can present their "deck" onscreen to students and also have the presentation simultaneously appear on each student's device. Students then answer questions individually on their devices, before the teacher reveals the answer or shares the answers from all students to the group. Teachers can prompt and maintain high rates of student participation with various classroom management techniques (e.g., quick response verbal questions, discussion before progression, locked student screens, all student response view).

Augmented reality applications could be used to support GN. With free and simple to use high tech tools teachers can construct a guided notes page, and then create brief videos with further explanation of various items linked to the printed GN page using an augmented reality app. Later students can use a smartphone or other device to "scan" the GN and view videos providing explanation or additional information.

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[1] Current educational examples include includes the Internet, computer hardware, software applications ("apps"), monitors and sensors, 3D printers, virtual and augmented reality, etc.

[2] For a quick tutorial see http://www.makeuseof.com/tag/how-to-use-google-forms-to-create-your-own-self-grading-quiz/.

Tools like Google Forms, Handouts, Pear Deck and many others are often considered formative assessment apps, involving frequent or real time student responses to teacher created (or peer/self-created) materials. These tools can be linked to learning management system (LMS) software to support the administration, management, delivery, and reporting of electronic instruction. Converting formative assessment programs to a GN format should be relatively easy; the skill and benefit comes from knowing how to create good Guided Notes questions. Ultimately the same considerations for paper-based GN (found in Fig. 6) apply to digital ones.

As noted earlier, the research base supporting the effectiveness of GN is quite broad and robust. The research base regarding electronic or digital guided notes is much smaller and less well defined. For instance, a comparison of pen and paper note taking (not GN specifically) to using note taking software yielded no clear outcomes; instead finding that classifying lecture notes is highly subjective and dependent on personal interpretations (Garbo, Mangiatordi, & Negri, 2012). An investigation of effects of "enhanced" (i.e., electronic) guided notes on shared note-taking and student social networks found that college engineering students who were willing to utilize both electronic and paper-based notes had similar self-regulated learning skills (Lawanto & Santoso, 2013).

Clearly more research is needed comparing the effectiveness of high versus low tech GN tools, as well as considering what variables are related to the effective use of high tech GN. A few of these features are listed below, which may be considered potential variables in the effective use of high tech GN.

- Teachers can electronically send GN to all, some, or individual students.
- Teachers can set timelines for completion, and know when GN are completed.
- Teachers can digitally view students completed GN.
- Teachers can set up automatic grading of GN.
- Teachers can create a library of GN and share with peers.
- Students can maintain a portfolio of completed GN.
- Students can receive immediate feedback on their GN.
- GN can be projected for group review.
- GN can be linked to video or other media for further review.
- GN can be included as part of a digital learning management system.

3.2. Response cards

Many high-tech or digital tools that emulate response cards go under the umbrella name of "student response systems" (SRS, or colloquially as "clickers."). Commercially available SRS consist of a receiver for the teacher and a keypad or response entry device for each student, and are often accompanied by software that supports onscreen projection and data collection. With most commercial SRS, a teacher develops multiple choice or selection-based questions on his or her device and displays them via a computer-connected projector. Students answer by pressing keys on their "clicker" (usually about the size and style of TV remote control). Various technologies support one-way or two-way infrared, radio frequency, or Internet enabled transmission. "One-way" technologies require students to watch the projected screen to see their own response or a

Runs on downloaded software	←→	Entirely browser based
Students must enroll in system	←→	Anyone with connected device can answer
Teacher must create questions prior to lesson	←→	Create spontaneous questions
Provides response feedback to individual students	←→	Provides group level feedback
Allows multiple responses	←→	Allows 1 response per student per question
Supports multiple question formats[1]	←→	Supports only text based multiple choice
Supports multiple response modes[2]	←→	Supports selection-based (multiple choice) responding only
Sets time limits for responding	←→	Allows responding at any time
Supports audio and video enhancement	←→	Does not support audio or video
Provides "game-like" functionality[3]	←→	Presents questions-responses only
Supports data collection	←→	Responses are fleeting
Supports individual responder data collection	←→	Supports group data only
Provides visual displays of response data	←→	Provides text summary
Maintains a data-base of responses over time	←→	Deletes data when session ends

Fig. 7. Features of "response card" apps.
[1]Such as multiple choice, True-False, Rating Scale, Slider, Open-ended (short or long text), Indicate/Draw, etc.
[2]Such as text entry, image upload, live drawing, as well as image or text selection.
[3]Such as earning points, leaderboards, challenges, etc.

summary of the group's responses. Two-way technologies send confirmation back to the student's device; some even provide specific feedback to students based on their individual responses (Johnson & McLeod, 2005).

In this era of personal computing and "Bring Your Own Device" (BYOD, Johnson, Adams Becker, Estrada, & Freeman, 2014) many educators and software designers are taking advantage of the ubiquity of smart devices[3] by having students use their own phones and tablets as electronic response cards. Numerous free and low-cost apps such as Kahoot (kahoot.it), Geddit (http://park.letsgeddit.com) or Exit Ticket (exitticket.org), are available that run on the web browser of any Internet accessible device. In many cases the apps or browser based student response system provide much greater functionality that seem to only enhance the effectiveness and capabilities of traditional active student responding tactics. For example, in addition to supporting multi-media, some apps support data collection and can share those data with online grade books or other protected systems for storing and analyzing student data. One app, Plickers (plickers.com), blends both high and low tech tools by having learners hold up printed cards, that are then scanned and scored by the camera on the teacher's handheld device. Data on each student's response and the entire class are stored in the system for the teacher to view or project.

High tech devices and software support experimentation and variation in what teachers can do with response cards. Fig. 7 lists features associated with Response Cards that are supported by current apps used on smart devices. Of course, the greatest impact on learning comes from good instructional design paired with high rates of meaningful active student responding.

The research base for electronic response cards is growing and predominantly positive. Stowell and Nelson (2007) compared an electronic audience response system (clickers) to standard lecture, hand-raising, and response card methods across the same 30-min intro to psychology lecture. The clicker group had the highest classroom participation, followed by the response card group, both of which were significantly higher than the hand-raising group and standard lecture. Interestingly, the researchers also found the clicker group participants were more likely to respond honestly during in-class review questions. An investigation of academic performance of 22 s grade students found the group using clickers showed a mean score gain over the group not using clickers. Additionally survey results indicated that students enjoyed using clickers and felt the clickers aided their performance (Scott, 2014).

A direct comparison of three ASR methods (clickers, response cards, and hand-raising) across four sections of a general psychology course found no significant differences between experimental conditions. Meaningful gains in exam performance appeared more related to the format with which questions were presented rather than to the use of any of the specific ASR modalities (Zayac, Ratkos, Frieder, & Paulk, 2016). Similarly, Anthis (2011) found question types and how questions are used during instruction to be more impactful than clicker use, suggesting that more variables warrant investigation before touting the positive effects of electronic student response systems. As previously noted, it is not the technology itself that makes a difference; it is how that technology is used. Electronic response cards can support or augment existing principles of good teaching across different disciplines and support teacher efficiency in all levels of education and facilitate active learning in both large and small classes.

3.3. Choral responding

In general it appears low tech strategies are the best route for occasioning high rates of student oral responding in unison. However, any of the technology options suggested above could generate and present content a choral response format, such as creating word lists, images, or questions posted on screen for group responding. Additionally educators could show video clips and pause for choral response opportunities about what is on screen or what was just seen.

Other high tech tools offer alternative means for increasing student responding and creating opportunities for oral responses from all students, albeit perhaps not simultaneously. For instance, the app VoiceThread**TM** (voicethread.com) allows users to post images or video, and supports voice recording and onscreen drawing from others. Teachers could post images of Washington crossing the Delaware for example, and assign students to record their comments regarding what the images are about, why the river was being crossed, what the men might have been thinking, etc. VoiceThread**TM** saves all the student recordings in one place for the teacher and the group to listen to at any time.

Apps that support adding student voice to images, videos, or user created drawings or animations are fairly common and often free. Easy to use high tech tools that encourage student vocalizations and save the recordings for playback and commenting include Chatterpix**TM** (http://www.duckduckmoose.com/educational-iphone-itouch-apps-for-kids/chatter-pix/) where users manipulate the "mouths" on images, to make it appear their recorded voice is coming from the picture; Voki**TM** (www.voki.com) where users create animations and moving mouths for recorded voice and text to speech, or Sock Puppets (https://itunes.apple.com/us/app/sock-puppets/id394504903?mt=8) where users create their own lip-synched videos. Although these apps do not support the rapid, high frequency, simultaneous responding so beneficial in choral responding, they support responding from each student and may facilitate increase vocal responding by students over time.

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[3] "Smart devices" can communicate with other devices or networks via WiFi, Bluetooth, or other wireless communication protocols.

3.4. Considerations for "high tech" strategies

Generally the same considerations that apply to low-tech strategies apply to high tech, for both the technology of tools and of the instructional process. Both high and low tech should strive to maximize meaningful student responding to well defined learning objectives, build in numerous practice opportunities, provide clear instruction and useful, contingent feedback, and provide some sort of measurement and analysis for informed instructional decision making.

The tools and applications mentioned above were selected due to their utility in increasing active student responding, with the instructional content determined by the teacher. However many 21st Century educators are also looking to apps for instructional content, focusing on skill acquisition or practice. Instructional apps teach specific information or particular skills to learners, often moving from establishing initial simple performances through building more complex performances. A paper highlighting effective education technology would be remiss if it did not offer the reader some guidelines regarding app selection. Variables to consider when selecting an instructional app include the following:

- *Clearly specified learning outcomes*: The app clearly describes skill that a teacher or parent can observe the learner *doing*. For instructional apps, content takes precedence over coolness, design, or excitement. Make sure the learning outcomes directly support the curriculum/lesson.
- *High rates of active student responding*: The app provides numerous opportunities for the learner to practice the skills related to the learning objective.
- *Differential Feedback*: The app provides immediate feedback following both correct and incorrect answers. Feedback is noticeably different for correct vs. incorrect answers, and incorrect answers are not more "fun."
- *Adaptive Difficulty*: The difficulty of the material increases and decreases automatically based upon the learners performance.
- *Mastery-based*: The learner achieves mastery of the current skill set before being progressing to the next level
- *Performance Reports*: Performance data on the target skill(s) are provided, with enough detail for a teacher or parent to know what the learner is doing and to target problem areas.
- *Usability:* The app should be easy to use, with simple prompts for how to interact with the interface. Images and sounds should be relevant to the learning activity, not distracting for the learner the reading level of the app should be appropriate for the lowest age of learner identified (Criteria for apps adapted from Mahon (2014) and Twyman (2014b)).

4. Improving learning right here, right now

Imagine the passion, excitement, and explosion in learning if teachers all over the world started using all these powerful, easy-to-implement tools in their classrooms right now. Research has shown that factors within a teacher's control, such effective instruction, can overcome unfavorable sociological factors and numerous other obstacles (Binder, 1991; Werner, 1994). Research has also shown us what works, hence we propose three specific, research-based teaching strategies that any teacher can begin using "right now" to increase learning in any classroom, whether resource rich or having only the bare necessities. We believe that using these strategies will bring us much closer towards the shared goal of literacy, numeracy, and all humans having basic social and life skills necessary to secure a job, to be an active member of a peaceful community, and to have a fulfilling life.

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