Student Response Systems for Formative Assessment: Literature-based Strategies and Findings from a Middle School Implementation

Julia S. Fuller
Kennesaw State University, United States

Kara M. Dawson
University of Florida, United States

Abstract

In this article we share how a district-level technology integration specialist used literature on implementing student response systems (SRS) for formative assessment, based on Desimone's (2009) core features of professional development design, Guskey's Levels of Professional Development Evaluation (1998, 2000, 2002), and Danielson's Observation Cycle (2007), to support 12 middle school teachers in using SRS in their classrooms. The work reported here provides an example of incorporating literature-based best practices to support teachers in effectively using technology in the classroom. The findings of this study indicate that the teachers learned to use the SRS technology and associated strategies to collect formative data and appropriately adjust instruction to meet learners' needs. This work has implications for SRS in K-12 classrooms, technology integration professional development, and for preservice teacher education.

Keywords*: Evaluation; Instructional design; Observation cycle; Professional development; Student response systems*

Introduction

Student response systems (SRS), sometimes referred to as handheld clickers and recently designed as web-based or mobile apps, are educational technologies used to collect student data – diagnostic, formative, or summative. As textual and/or numerical data are collected via multiple choice or open-ended questions, SRS maintain anonymity among the student responders when teachers displays the charted data, but also provide individualized data for the instructor to review. Especially when literature-based strategies are used for SRS formative data collection, the learning process may be enhanced such that students are engaged and reflective while teachers receive information for modifying instructional pacing or content to immediately meet learners' needs (Polly, Rodgers, & Little, 2015; Penuel, Boscardin, Masyn, & Crawford, 2007). The ability for a technology to enable formative assessment in this manner is desirable to students and teachers alike. However, as with all educational technologies, teachers must be adequately prepared to use SRS or else they may go unused or, possibly, inappropriately used in classrooms (Williams & Kingham, 2003).

Purpose of the Study

The impetus for the work reported herein was a district-wide purchase of SRS for use by teachers who historically had minimal opportunities for practicing technology integration because allotment of resources and support for teacher education at the district, state, and collegiate levels had not been consistent and, in some instances, had been non-existent. The teachers in this district had never used the SRS technology before yet administrators expected the technology to be used consistently and effectively.

At the time of this work, the first author was a district-level technology integration specialist and a doctoral student. As part of her doctoral work she conducted a needs assessment of middle school teachers in the district as related to SRS and learned that they lacked knowledge on how to use the SRS for formative assessment and student engagement in their classrooms. She was aware that learning a new technology is difficult and effective integration would likely not occur without appropriate support (Williams & Kingham, 2003). Additionally, she knew that a lack of technology-supported pedagogical knowledge is an identified hindrance to technology integration and that conducting professional development is a strategy to overcome this barrier (Hew & Brush, 2007). Therefore, the overarching research question for the study was the following: In what ways will professional development based on literature-based best practices help middle school teachers to effectively implement SRS for formative assessment and student engagement? The two guiding research questions for this study evaluating the effect of the professional development are:

1. In what ways are the teachers using the student response system for formative assessment?
2. What effect did the teachers' instructional use of SRS have on student engagement?

Consequently, she worked to carefully design and evaluate professional development for 12 middle school teachers to promote literature-based practices related to using SRS for formative assessment. In this article we share SRS literature used to inform the professional development as well as details about its design, evaluation, and outcomes. We then share the implications this work has for others in terms of SRS in K-12 classrooms, technology integration professional development, and preservice teacher education.

Literature Review

SRS for Formative Assessment

Fies and Marshall (2006) assert that research is limited regarding the use of SRS for formative assessment. This is particularly true in primary and secondary schools, however, an exploratory study by Polly, et al. (2015) found that using SRS in an elementary mathematics classroom helped the teachers with formative assessment by providing data to inform the direction of instruction and track students' progress. For collecting these formative data, the literature suggests between three and six clicker questions for a 50-minute lesson (Beatty & Gerace, 2009; Bruff, 2009a). Pacing the questions appropriately between segments of content allows a teacher to create an opportunity for formative data collection in which students demonstrate their understanding of each segment.

Additionally, pacing the questions rather than asking them all at once keeps the students attentive and engaged throughout the lesson.

There are also instructional strategies that, when used with SRS, will provide immediate formative assessment data. Each of these strategies incorporates SRS for formative assessment by providing an avenue to collect data and an approach for adjusting instruction. Three such strategies include:

- Contingent/Agile Teaching (Bruff, 2009b; Beatty, Gerace, Leonard, & Dufresne, 2006; Draper & Brown, 2004)
- Discussion Warm-up (Bruff, 2009a, 2009b)
- Peer Instruction (Bruff, 2009a, 2009b; Mazur, 1997)

Penuel et al. (2007) found that teachers tend to use SRS to gauge students' comprehension and determine misunderstandings, display response data for facilitating student reflection and discussion, and adjust instruction based on the response feedback -- all of which align with these three approaches and help promote student engagement.

Contingent/Agile Teaching

When using the Contingent/Agile Teaching strategy (Beatty et al., 2006; Bruff, 2009b; Draper & Brown, 2004), as the teacher instructs he or she collects real-time SRS data to monitor student achievement via the technology's charting feature and then uses that readily viewable data to modify instruction immediately. For example, teachers may proceed with a class discussion, show a focused video on the topic, or ask a follow-up clicker question to reteach or extend learning based on the students' responses.

Such formative use of SRS is documented as effective in an empirical study by Draper and Brown (2004), in which collegiate students in a variety of disciplines identified this pedagogical approach as beneficial. According to these authors, the defining attribute of this strategy is the teacher's ability to vary instruction based on student needs rather than following a pre-determined instructional sequence. Therefore, as the teacher responds to students' learning needs by using a variety of approaches to help students master learning objectives, the students become engaged in the learning process.

Discussion Warm-up

The Discussion Warm-up strategy (Bruff, 2009a, 2009b) also helps a teacher monitor the students' progress. When using this strategy an initial question posed by the teacher stimulates the students' thinking about the topic thereby facilitating formative data collection. The teacher then gives the students sufficient time to submit his or her response to the question using the SRS, which helps to increase the participation of all learners as students have time to decide upon a response prior to the discussion. The increased participation that results facilitates student engagement as learners critically consider the content. Additionally, the resulting SRS data helps the teacher to identify the

students' understandings and misinterpretations for guiding the discussion appropriately, as well as to design future instruction to meet learners' needs.

Peer Instruction

The Peer Instruction strategy (Bruff, 2009a, 2009b*;* Mazur, 1997*)* helps students learn content that is more difficult. For this strategy a teacher involves the students in an instructional sequence of questioning, peer interaction, and class-wide discussion to help the group understand the material. Once a question is posed, the anonymous response data are revealed to the class in the form of a chart. If there is a lack of understanding among the group, the teacher partners up the students for a peer discussion. After a few minutes of conversation, the students re-vote using the SRS. This interaction engages the entire class and provides formative data to the teacher, which helps guide the follow-up class discussion. An extensive survey study by Fagen, Crouch, and Mazur (2002) found significant learning gains and engagement among college students with use of this strategy.

Web-based SRS

While literature on using SRS for formative assessment in K-12 settings is scarce, the use of these tools for assessing student learning is likely to increase due to their availability on the Internet and their ability to engage learners during assessment. Web-based SRS tools are accessible to users from a phone, tablet, computer, or other device with Internet capability. A study on using the Nearpod (2017) application, a presentation tool with certain SRS capabilities, during elementary guided reading found that the technology helped teachers monitor their students' progress (Delacruz, 2014). This particular technology allows teachers to ask multiple choice or open-ended questions, as well as have students draw a visual response to demonstrate their knowledge of a concept while collecting data instantaneously. In another study, survey data from students in a higher education setting suggested that the web-based SRS called Socrative (2017) provided instant feedback regarding students' knowledge (Walsh, 2014). The charted feedback from this technology not only helped students to self-reflect on their learning, but also helped teachers to formatively assess their students and adjust their instruction accordingly. Rebecca, Andrea, and Jermaine (2014) used the data collected via Socrative to immediately address their secondary students' misconceptions, which were evident from the responses received. Lastly, both Socrative and another SRS tool called Kahoot! (2017) have game-based features. A study by Wang (2015) conducted in a Bring Your Own Device (BYOD) classroom identified the competition element of Kahoot! as the main element for sustaining attention during instruction when using the tool.

Although there are differences among SRS tools, one similarity among them is the capability for learners to respond to a question or a series of questions while the system collects and compiles their answers in real time. Therefore, regardless of whether it is a hand-held clicker or web-based software accessed from a computer or mobile device, SRS have the capability to provide formative assessment data to teachers that is instantaneous and helpful for guiding instruction, as well as engaging learners when strategies such as those mentioned herein are utilized.

Methods

Participants

The participants consisted of teachers from two middle schools in one southeastern school district who attended the professional development sessions and consented to participate in the study (N=12). The participants were 100% female; however, their years of experience teaching and college preparation level varied. The participants' mean years of experience teaching in Georgia at the time of the study was 16.08 with the frequency distribution as follows: 1 teacher with 1-5 years, 3 teachers with 6-10 years, 4 teachers with 11-15 years, and 4 teachers with 21 or more years. The degree level of two participants was unknown (n=2), and all others held a graduate degree: masters (n=7), specialist (n=2), or doctorate (n=1). The participants' teaching assignments represented each grade level: 6^{th} grade (n=5), 7^{th} grade (n=3), 8^{th} grade (n=3), and one taught both 6^{th} and 7^{th} grade (n=1). The participants also represented every core content area – mathematics (n=3), science (n=3), social studies (n=3), and language arts (n=3). The "convenience sampling" strategy (Patton, 1987) was used, as the teachers were naturally present in the setting of the study. This sampling strategy is typical in evaluating professional development.

SRS Professional Development Design

Appropriately designed and implemented instruction for teachers can affect students' knowledge gains (Hill, 2007). An example is when professional development helps teachers use instructional technologies to enable best practices and thereby facilitate student success. The literature on professional development pinpoints specific valuable components for adult learners. A review of empirical studies by Desimone (2009) describes a core set of features for effective professional development in a variety of contexts. The framework components include (a) content focus, (b) active learning, (c) coherence, (d) duration, and (e) collective participation. Desimone (2009) suggests a relationship between increased teacher knowledge, instructional changes, student improvement, and these core professional development features.

These core features were embedded in each professional development session conducted by the technology integration specialist, as shown in Table 1, and each session used a similar approach to provide consistency among the sessions. Additionally, the instruction was aligned to the state's teacher evaluation standards for effective formative assessment and technology integration. Therefore, during each session the first author facilitated discussions to help the teachers consider ways to use their SRS to collect formative data for assessing their students' progress. She also incorporated the three aforementioned literature-based strategies into the instruction to guide teachers' use of the SRS. The general instructional sequence of activities for the sessions was as follows:

1. Introduce an aspect of the SRS technology and a literature-based strategy for using the tool formatively.
2. Lead a discussion and cooperative activity to generate ideas regarding the impact of technology-integrated formative assessment on student achievement and engagement.

3. Facilitate an opportunity for teachers to experiment with the SRS technology and the literature-based assessment strategy.
4. Provide time to work on a multimedia lesson that incorporates formative assessment strategies using SRS.

This teacher-developed multimedia lesson was for their classroom use and demonstrated each teachers' ability to integrate formative assessment strategies via the SRS. The teachers worked on their multimedia lesson artifact during each of the sessions and received feedback from peers and the instructor during the process. Resources for helping the teachers incorporate SRS for formative assessment in their lesson designs were posted online and used during the sessions, as well as available for future reference.

Table 1. Desimone's (2009) Core Features of Professional Development (PD) and SRS PD

Core Features	Definition	Ways in Implemented in the Professional Development	Other Supporting Literature for the Feature
Content Focus	PD programs should emphasize both subject matter content and how students learn the content.	Teachers were provided suggested strategies for use in different content areas and practiced using SRS within their discipline.	Desimone, Porter, Garet, Yoon, & Birman, 2002; Garet, Porter, Desimone, Birman, & Yoon, 2001; Hirsh & Killion, 2009; Hughes & Ooms, 2004; Sparks, 2002
Active Learning	PD programs should actively involve teachers in the learning process.	Teachers developed and implemented a multimedia lesson artifact.	Bradshaw, 2002; Desimone et al., 2002; Garet et al., 2001; Hirsh & Killion, 2009; Mouza, 2003
Coherence	What is taught in the PD program should align with state and district goals and standards for student learning.	The PD was meaningful and explicitly aligned to using SRS to support state and district standards. In addition, the SRS were purchased district wide.	Borko, 2004; Desimone et al., 2002; Garet et al., 2001; Hill, 2007; Killion & Harrison, 2006; Knowles, Holton, & Swanson, 1998
Duration	PD programs of longer duration should be emphasized over short-term workshops.	The PD included four sessions with opportunities for classroom implementation in between and culminated with an observation cycle that included support in the classroom during one or more lessons as requested by the teacher.	Borko, 2004; Desimone et al., 2002; Garet et al., 2001; Killion & Harrison, 2006; Lee 2005

Collective Participation	Teachers should work together during PD programs.	Teachers had time during the professional development sessions to collaborate on using the technology-based formative assessment strategies and were supported with feedback on their ideas.	Ball, 1996; Desimone et al., 2002; Garet et al., 2001; Guskey, 2003; Hill, 2009

Data Collection: SRS Professional Development Evaluation Framework

Guskey's Five Levels of Professional Development Evaluation (1998, 2000, 2002) was used as a framework for assessing the SRS professional development. This model includes five critical levels of information for evaluating professional development in educational settings. The data collection process becomes more complex at each level and generally requires success before the next level may be considered (Guskey, 2002). The evaluation begins with determining the participants' general reactions to the professional development, moves to gauging the learning experience, and then assesses how the organization supports change. The next level evaluates the teachers' application of new knowledge or skills, and the last level examines the impact on student learning, or in this case student engagement during the SRS lessons. When evaluating these last two levels, referred to as Levels 4 and 5, participants must be allowed enough time to incorporate the new ideas into their practice (Guskey, 2002).

This study, part of a larger professional development evaluation study implementing all five evaluation levels, focuses on Level 4 and Level 5 of the evaluation model. Because data at these levels are collected after significant time has passed following the professional development, it is more difficult to implement these evaluation levels (Gordon, 1991). Consequently, many professional development evaluations focus only on the earlier levels (Cody & Guskey, 1997), and this study seeks to fill that gap in the literature. Additionally, these last two levels provide the most significant data regarding the effectiveness of the professional development being evaluated, as they address the participant's sustained implementation of their learning and how these new instructional practices resulting from the professional development ultimately impact students.

Table 2 shows the guiding questions and data collection strategies aligned with each of the five levels of the larger evaluation study. This study focusing on Levels 4 and 5, bolded within the table, seeks to answer the overarching research question: In what ways will professional development based on literature-based best practices help middle school teachers to effectively implement SRS for formative assessment and student engagement?

Observation Cycle for Data Collection at Levels 4 and 5

Danielson's (2007) three-part observation cycle was used to determine how teachers used SRS for formative assessments (Level 4 question) and how teachers' use of these strategies influenced

student engagement (Level 5 question). The three-part cycle consisted of (1) a pre-observation interview, (2) a direct observation, and (3) a post-observation interview.

Table 2. Alignment of the Five Evaluation Levels, Guiding Questions, and Data Collection Methods for the Larger Professional Development Evaluation

Guskey's Five Levels of PD Evaluation	Guiding Questions	Data Collection
Level 1: Participants' Reactions	What are the teachers' perceptions about the professional development?	Perceptions Questionnaire
Level 2: Participants' Learning	In what ways did the teachers acquire the intended knowledge?	Teacher Multimedia Artifact Rubric
Level 3: Organization Support and Change	In what ways does the organization help teachers implement the technologies?	Organization Support Questionnaire
Level 4: Participants' Use of New Knowledge and Skills	**In what ways are the teachers using the student response system for formative assessment?**	**Observation Cycle: Pre-Observation Interview Protocol; Observation Field Notes Guide; Direct Observation Rubric**
Level 5: Student Learning Outcomes	**What effect did the teachers' instructional use of SRS have on student engagement?**	**Observation Cycle: Observation Field Notes Guide; Post-Observation Interview Protocol**

Pre-Observation Interview

The pre-observation interview protocol was used to help the researcher understand the lesson that was about to be observed (Danielson, 2007). Standardized open-ended questions (Patton, 1987) were used to help the researcher gain insights into how and why the teacher designed the lesson and planned for the use of SRS within it. These questions enabled the researcher to triangulate the data gained through the observations (Fraenkel & Wallen, 2006). For example, one interview question asked teachers to explain how they planned to use SRS for formative assessment. The researcher was then able to observe the lessons and see how the teachers' intentions played out in practice. Pre-observation interviews occurred one to two days before the observations and lasted about 30 minutes. All of the interviews were transcribed by the first author.

Direct Observation

Direct observations occurred within a day or two after the pre-interview and to "get a full description and deep understanding" (Glense, 2006, p. 51), each observation lasted about an hour or the full length of the lesson. A rubric was designed to assess how well the teachers were meeting the two state teacher evaluation standards focused on in the professional development:

- The teacher uses accessible technology effectively to enhance student learning.
- The teacher uses formative assessment strategies to monitor student progress and to adjust instruction in order to maximize student achievement.

The rubric in Figure 1 includes descriptors for four levels of proficiency with each standard: Not Evident, Emerging, Proficient and Exemplary as well as indicators of what each level may look like in practice. The four different levels were assigned numerical codes from 0-3: Not Evident (0), Emerging (1), Proficient (2), Exemplary (3).

Table 2. Direct Observation Rubric

SBI. 1.5 The teacher uses accessible technology effectively to enhance student learning. AL 1.2 The teacher uses formative assessment strategies to monitor student progress and to adjust instruction in order to maximize student achievement on the state performance standards.					
Teacher Evaluation System Continuum of Improvement		**Not Evident**	**Emerging**	**Proficient**	**Exemplary**
	SBI 1.5	The teacher does not use accessible technology to enhance student learning.	The teacher uses accessible technology; however, technology is used primarily with the whole class, select students, or as a tool for tutorials and drill.	The teacher routinely uses accessible technology to enhance student learning and support their achievement.	The teacher develops, implements, and evaluates a comprehensive approach for using accessible technology to enhance learning and achievement for all students.
	AL 1.2	The teacher does not use formative assessment strategies either to monitor student progress or to adjust instruction to meet student needs.	The teacher uses some formative assessment tasks and tools to guide adjustments of whole-class instruction; however, formative assessment is rarely used at the individual level or may be inconsistently implemented.	The teacher consistently uses formative assessment tasks and tools to monitor student progress over the course of most units and to adjust instruction to meet students' individual learning needs relative to GPS.	The teacher consistently uses a variety of formative assessment tasks and tools to monitor student progress over the course of all units and adjusts instruction to maximize student achievement relative to GPS for all learners. The teacher also involves students in decisions about adjustments to instruction to enhance their learning.

Examples of Evidence Aligned to Continuum	**Indicators:** The teacher… ○ does not use the provided technologies. ○ uses clicker questions that are not guided by GPS aligned lessons.	**Indicators:** The teacher… ○ employs clickers for whole class summative assessment (e.g. giving a test) or game. ○ delivers clicker questions during direct instruction. ○ uses some charts or other instant feedback to monitor student learning and adjust instruction.	**Indicators:** The teacher… ○ delivers GPS aligned clicker questions during direct instruction. ○ consistently uses charts or other data to monitor individual student learning and adjust instruction. ○ or uses the mobile interactive whiteboard screen to monitor learning of individual students and the class and adjust instruction.	**Indicators:** The teacher… ○ consistently implements each of the proficient indicators. ○ uses a variety of questioning strategies with clickers. ○ uses clicker data to facilitate student reflection about their own learning and involves them in instructional decisions.

Note: Format modeled after Rubric for Evaluating North Carolina Teachers (North Carolina State Board of Education, 2007). Incorporates the 2011 state teacher evaluation standards used in the study.

In addition to the rubric, a field notes guide (Bogdan & Biklen, 2007) was used to help the researcher further focus her observations. This guide included space for the researcher to document specifics of how the teachers used SRS for formative assessment and how engaged the students were in the lesson.

Post-Observation Interview

The post-observation interviews occurred immediately after or within a day of the observations, and standardized open-ended questions (Patton, 1987) enabled the researcher to understand the teachers' perspectives on how the lessons went and on student engagement within them. For example, teachers were asked to reflect on how they knew whether students were learning during the lesson and how they adjusted instruction accordingly. All of the interviews were transcribed by the first author.

Data Analysis

Thematic analysis, "a method for identifying, analyzing, and reporting patterns (themes) within data" (Braun & Clark, 2006, p. 6) was used to identify how teachers used SRS for formative assessments (Level 4 question) and how teachers' use of these strategies influenced student

engagement (Level 5 question). Braun and Clark's six-step process for using thematic analysis was employed, however, it is important to note that the process is iterative rather than linear (2006). First, all data (i.e. the pre- and post-interview transcripts, the observation rubric, and field notes) were read and reread to develop a strong familiarity with them. At this time the researcher also developed a frequency distribution of the participants' level of proficiency (i.e. Not Evident, Emerging, Proficient, and Exemplary) with the two state standards described above using the observation rubrics. Then, initial codes were generated keeping the focus of the research questions in mind. Themes were then generated from interpretative data analysis using an iterative process of identifying themes, searching for evidence to confirm (or disconfirm) them and defining, and naming and describing them.

Results

Results from Level 4 and Level 5 of the evaluation are presented here; however, it worth noting that within the context of the full evaluation all teachers reported positive perceptions about the professional development (Level 1), demonstrated proficiency in designing lessons aligned to SRS best practices (Level 2), and felt the district was providing adequate support for them to use SRS in their classroom (Level 3).

Level 4: In What Ways Are the Teachers Using the Student Response System for Formative Assessment?

Themes for Level 4 focused on how the teachers planned for and used SRS for formative assessment during instruction, including a variety of the PD strategies, and their demonstrated proficiency with the targeted teacher evaluation standards.

Teachers Implemented a Variety of SRS Formative Assessment Strategies from the PD

The data indicated that the majority of teachers became proficient in their ability to implement SRS for formative assessment to help students learn. During the pre-observation interview, coded transcription data revealed that the teachers were planning to use SRS for formative data collection and to adjust their instruction as a result. Most teachers implemented their plans accordingly during their lessons.

During the lesson observations, teachers were implementing the literature-based questioning strategies with the SRS, as shown in Table 3, for the purpose of collecting data to use formatively during their lessons. Teachers were observed using the SRS charting data for monitoring student progress and making instructional adjustments as they incorporated the strategies from the professional development.

Table 3. Examples of Strategies Used During Observations

Participant	Content Area	Lesson Topic	SRS Formative Strategies
1	Language Arts	Explanatory Writing	None
2	Language Arts	Literary Analysis	Contingent/Agile Teaching
3	Language Arts	Figurative Language	Contingent/Agile Teaching
4	Mathematics	Linear Equations	Contingent/Agile Teaching
5	Mathematics	Geometry	Contingent/Agile Teaching
6	Mathematics	Line Symmetry	Contingent/Agile Teaching
7	Science	Currents	Discussion Warm-up
8	Science	Botany	Peer Instruction; Discussion Warm-up
9	Science	Physical Science	Discussion Warm-up
10	Social Studies	Africa	Contingent/Agile Teaching
11	Social Studies	Cultures	Discussion Warm-up
12	Social Studies	Post-war Era	Contingent/Agile Teaching

As noted in Table 3, during the observation of Participant 6, the teacher implemented the Contingent/Agile Teaching clicker strategy (Bruff, 2009b; Beatty et al., 2006; Draper & Brown, 2004) during the instruction. The multimedia lesson had content slides alternating with embedded SRS questions, and the teacher used the resulting SRS charted data to identify and address weakness among the students, or opportunities for extension, before moving forward with the lesson. After the teacher presented a concept, she displayed a geometric shape or authentic image within the presentation. For each symmetry example, the students had a corresponding example on their paper for hands-on analysis. The teacher posed SRS questions to engage the students in reflecting on the lines of symmetry for each example and responded appropriately to the learners' needs based on the responses received via the SRS clickers.

Another teacher, Participant 8, was observed using the Peer Instruction clicker strategy (Bruff, 2009a, 2009b; Mazur, 1997) to monitor progress and assist students in learning botany concepts. As she discussed each of the flower's characteristics, she asked probing questions to determine the student's level of understanding of the functions, facilitated peer interaction by having students discuss their ideas with each other, and made connections to other scientific concepts through class-wide discussion. The teacher asked an appropriate number of SRS questions aligned to the content, and pacing was such that formative assessment data was readily available to help clarify misconceptions about the parts of the flower and their functions.

Teachers Demonstrated Proficiency with the Targeted State Standards by Using SRS

During the lesson observations, the data indicated that the majority of teachers were implementing research-based strategies found in the literature including collecting formative data, monitoring student progress, adjusting instruction, and engaging students in learning by involving them in the lesson. One way in which the majority of teachers demonstrated such strategies aligned to the teacher evaluation standards was by displaying the charted SRS data and discussing the results with the class. The teachers also used the SRS data to adjust the instruction through descriptive feedback by rephrasing concepts, explaining correct or incorrect answers, re-teaching difficult material, and

giving additional examples of misunderstood concepts. The teachers consistently asked additional questions beyond their planned SRS questions to facilitate discussion among the students.

For example, Participant 6 was observed implementing SRS questions in a symmetry PowerPoint during a mathematics lesson. The presentation included examples, non-examples, and symmetry problems for students to solve including SRS questions directly aligned to the student performance standards. The students used the SRS to submit their answers to the questions about symmetry. The pacing of the questions and the use of technology was such that the teacher was able to immediately clarify misconceptions through re-teaching (Beatty & Gerace, 2009; Bruff, 2009b) and further questioning.

Similarly, as Participant 8 implemented her botany lesson, she used the charting feature of the SRS to facilitate the students' reflection about their own learning and adjust instruction as needed. The teacher gave descriptive feedback by rephrasing definitions and concepts, explaining correct or incorrect answers, and giving additional examples of the science concepts. Additionally, this teacher included a SRS discussion question at the end of the botany lesson for gauging students' thoughts about the instructional strategies used in the lesson in order to involve them in future instructional decisions.

Table 4 displays data for the participants' scores on the classroom observation rubric (Figure 1). The rubric's standards and example indicators were used to guide the scoring process. To earn a rating of Emerging, the SRS was used primarily for drill and practice with minimal use of data for formative assessment. A rating of Proficient was assigned when the teacher consistently used the SRS to ask questions aligned to the student performance standards, deliberately used the data to monitor learning and adjust instruction, and implemented one literature-based SRS strategy. An Exemplary rating indicated that the teacher used multiple strategies and also involved students in reflection on their learning based on the data reviewed in class. One teacher scored Emerging on the Direct Observation Rubric. Of the 12 teacher participants, 10 scored Proficient and one scored Exemplary on the rubric. These frequencies indicate that 8.33%, 83.33%, and 8.33% scored Emerging, Proficient, and Exemplary, respectively.

Table 4. Frequency Data for the Observation Rubric

Rating	Frequency (N=12)	Percent of Observed Population
Not Evident	0	0.00%
Emerging	1	8.33%
Proficient	10	83.33%
Exemplary	1	8.33%

Level 5: What Effect Did the Teachers' Instructional Use Of SRS Have on Student Engagement?

The themes for Level 5 address the participants' use of SRS for engaging their learners, as well as their thoughts about the experience in terms of the effectiveness of SRS for engagement during instruction.

Teachers were Proficient with Engaging Learners through Questioning Techniques

The Level 5 observation field notes data indicated that the majority of teacher participants were proficient with engaging learners through questioning techniques. Examples of unengaging techniques include asking a question without follow-up or asking too many at once. These teachers asked an appropriate number of sufficiently-paced SRS questions (Beatty & Gerace, 2009; Bruff, 2009a). Then, they followed with descriptive feedback such as rephrasing concepts, explaining correct or incorrect answers, and providing additional examples of the concept to aid learners' understanding. Their SRS questioning strategies also enabled engagement as students considered, responded, and discussed.

Additionally, teachers engaged learners in reflection of their own learning by displaying the charted data and facilitating a discussion of it. The teachers asked questions such as, "Explain why letter A is not the correct option" or "Explain why you selected letter C." Such prompts by the teacher helped students to critically analyze their thinking about the content; and therefore, engaged them in the learning process.

Student Behaviors Indicated Engagement during use of the SRS Technologies

The students' observed behaviors indicated overall engagement during the learning process as they used the SRS. Coded student behaviors indicating engagement during use of the technologies included: Answering the teacher's questions with SRS technology, responding to the charted SRS data, and discussing the SRS questions with other students. The students made comments about the charts showing interest in the progress of the class and were on-task when discussing the content.

Although the use of SRS produced an engaging learning experience, unengaged behavior was noted by the researcher. For example, occasionally one or more students were observed not using their SRS to respond to a teacher's question until prompted by the teacher.

Teachers Believed that the Technology Facilitated Their Students' Engagement

The post-observation interview data for Level 5 supported what was already observed in the classrooms regarding student engagement. During the post-observation interviews the teachers indicated that the technology helped the students to learn and reflect on their learning while providing instant feedback, both of which facilitated their students' engagement. The teachers affirmed that students were engaged with using the SRS due to the accountability for participation, even with the anonymity of the charting, as the students knew their teachers could review identifiable data afterwards. The teachers also indicated that their students remained engaged during the lesson as a result of using the literature-based formative assessment strategies with the SRS.

Specifically regarding learning outcomes resulting from student engagement with the SRS, the teachers stated that the SRS data helped reveal students' progress throughout the lesson, as well as to determine whether re-teaching the content was needed. The coded post-observation interview data also revealed that the teachers recognized their students were learning based on their SRS responses and engaging participation in follow-up discussions.

Limitations

The researcher attempted to increase the trustworthiness of the study and limit researcher bias by assessing interpretations of the data and remaining objective (Glesne, 2006). To increase validity the researcher collected data at two middle schools. Additionally, the researcher achieved validity through triangulation (Denzin, 2006) -- carefully inspecting and interpreting multiple sources of data.

Limitations include the sole focus on using SRS for formative assessment. This limited focus may have led to overlooking other valuable uses of the technology or additional instructional strategies. Another limitation of the study is the sample size because it may not accurately reflect the thoughts or abilities of all teachers in the two schools. Additionally, in determining the study's sample, the researcher failed to consider the teachers' ability, such as his or her previous difficulty with formative assessment strategies, limited use of the technology, or teaching expertise; however, the teachers had not received previous professional development on the topic. Because the participants volunteered for the study, their motivation or prior knowledge and instructional practice may vary from non-participants in the schools, which may have resulted in selection bias (Wayne, Yoon, Zhu, Cronen, & Garet, 2008).

Discussion and Implications

The work reported here is an example of how specialists on-site can integrate literature-based best practices for technology use and for professional development design and evaluation to support teachers in effectively using technology in the classroom. Implementing Guskey's research-based evaluation model provided insight into the effectiveness of the professional learning provided by the technology integration specialist and facilitated reflection on ways to improve future professional development in the district. The observation cycle helped gauge participants' use of their new knowledge and skills for effectively implementing the SRS for formative assessment such that future professional development could be designed to further their learning. This process also initiated consideration regarding the impact of such technologies on student engagement learning outcomes. As we will discuss here, the work has implications for SRS in K-12 classrooms, technology integration professional development, and for preservice teacher education.

SRS in K-12 Classrooms

Prior to this professional development, the middle school teachers reported mainly using SRS for quizzes, tests, homework collection, and for proposing question after question. While these

approaches may have merit, the literature suggests a more effective and engaging use of SRS involves implementing various strategies to formatively assess learning. The three SRS strategies taught during this professional development may help other teachers who desire to use the tool in ways that are more productive. Similarly, such techniques not only prove valuable for engaging learners in content, but also for helping students reflect on their own learning as well as helping each other learn. Given that differentiation strategies yield from formative data, using SRS to enable data collection and formative assessment provides teachers with information, in the form of individually identifiable response reports, to effectively differentiate instruction for their students. Since these tools are effective for formative assessment and student engagement, additional research on the use of these tools in K-12 settings could further support their use during instruction by identifying additional approaches for their use during the learning process. With the availability of web-based SRS, the previous expense of clicker hardware is eliminated, and conducting such research in BYOD or mobile device environments is becoming a viable alternative.

Technology Integration Professional Development

The literature-based strategies (Table 1) used in the design of this technology integration instruction are important to apply regardless of the tool being learned. More often than not, technology-based instruction focuses on step-by-step learning, which is generally perceived as ineffective. Whereas collaborative, active opportunities over an extended time for learning to use a particular technology for supporting learning can enable content mastery with a focus on standards. These strategies are helpful to teachers for sustaining their ability to implement a new technology during instructional practice. Additionally, an in depth professional learning evaluation helps to ensure this is the case, as teacher application of those new skills and the effect on student learning is determined.

In particular, this work implicates the need for professional development on using SRS. Web-based SRS are commonly available and with appropriate support, teachers learn to use SRS in ways that benefit students. For that reason, it is imperative that we prepare teachers such that they are able to use these tools effectively in their classroom. In the survey study by Penuel, et al. (2007), 498 elementary and secondary teachers reported that teachers who frequently used SRS in combination with various instructional strategies were more likely to have participated in professional development. These teachers were also more likely to report the SRS as effective tools in the classroom. A similar conclusion may be drawn about the educators discussed herein thereby supporting the need for preparing teachers to use SRS for formative assessment. Additional studies using Guskey's model to evaluate technology-based professional development in K-12 settings would add to the literature on effective professional development design and positively impact teachers' ability to innovatively use technology during instruction.

Preservice Teacher Education

Coursework for preservice teachers on integrating SRS can help these future educators to design lessons using the technology for assessing student learning and monitoring progress. To that end, preparing preservice teachers with formative assessment strategies for integrating SRS can facilitate their use of the technology to assess and monitor learning, which is an important skill for our

educators as evidenced by its inclusion in teacher effectiveness standards. The benefit of using SRS during this process is the timeliness of the data received and the tracking of individual progress, which cannot easily be accomplished through manual methods. Reasonably, knowing many preservice technology courses have been designed as tool-based courses, this study provides support for including pedagogical uses of technologies in such courses, as the instructional strategies incorporated into this study were most significant in facilitating the teachers' effective uses of the SRS.

Modeling and teaching formative use of SRS in teacher education programs and courses helps candidates feel confident about using the tools upon entrance into the classroom. Additionally, instruction on using technology for formative assessment can support teacher candidates' completion of edTPA (Pearson, 2017), a performance-based assessment system for evaluating aspiring teachers, when specific pedagogical strategies are incorporated that help the preservice teachers assess student learning. Because the nature of the technology is to provide data to help teachers monitor individual and aggregate student progress thereby allowing the teacher to then modify instruction, using SRS may provide documented evidence of a teacher's ability to differentiate instruction based on formative data. Additionally, research on the impact of including SRS instruction in preservice teacher education courses could provide valuable information for teacher education programs.

Conclusion

The evaluation of professional development is essential. As noted by Guskey and Yoon (2009), critical evaluation of professional development helps determine its effectiveness, as studies reveal a connection between student learning and professional development adequately designed and implemented. Similarly, with technology-based learning it is critical that instructors remain knowledgeable of and incorporate the most recent tools available – in this case web-based SRS – to support effective teaching strategies. By incorporating SRS and other technologies into preservice programs and K-12 educator professional development, teachers will be prepared to use and will effectively incorporate educational technologies into their classrooms.

References

Ball, D. L. (1996). Teacher learning and the mathematics reforms: What we think we know and what we need to learn. *Phi Delta Kappan, 77*(7), 500-508.

Beatty, I., Gerace, W., Leonard, W., & Dufresne, R. (2006). Designing effective questions for classroom response system teaching. *American Journal of Physics, 74*(1), 31-39.

Beatty, I. D. & Gerace, W. J. (2009). Technology-enhanced formative assessment: A research-based pedagogy for teaching science with classroom response technology. *Journal of Science Education & Technology, 18*(2), 146-162.

Bradshaw, L. (2002). Technology for teaching and learning: Strategies for staff development and follow-up support. *Journal of Technology and Teacher Education, 10*(1), 131-150.

Braun, V. & Clark, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77-101.

Bogdan, R. & Biklen, S. K. (2007). *Qualitative research for education: An introduction to theory and practice* (5th ed.). Boston, MA: Pearson Education Group.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher*, *33*(8), 3-15.

Bruff, D. (2009a). *Teaching with classroom response systems: Creating active learning environments*. San Francisco, CA: Jossey-Bass.

Bruff, D. (2009b*). Vanderbilt University Center for Teaching.* Retrieved on 6 February 2017 from http://www.vanderbilt.edu/cft/resources/teaching_resources/technology/crs.htm.

Cody, C. B. & Guskey, T. R. (1997). Professional development. In J. C. Lindle, J. M. Petrosko, & R. S. Pankratz (Eds.), 1996 *Review of research on the Kentucky Education Reform Act* (pp*.* 191-209). Frankfort, KY: The Kentucky Institute for Education Research.

Danielson, C. (2007). *Enhancing professional practice: A framework for teaching* (2nd ed.). Alexandria, VA: Association for Supervision and Curriculum Development.

Delacruz, S. (2014). Using Nearpod in elementary guided reading groups. *Tech Trends 58*(5), 62-69.

Denzin, N. (2006). *Sociological methods: A sourcebook* (5th ed.). Piscataway, NJ: Aldine Transaction.

Desimone, L. M., Porter, A. C., Garet, M. S., Yoon, K. S., & Birman, B. F. (2002). Effects of professional development on teacher instruction: Results from a three-year longitudinal study. *Educational Evaluation and Policy Analysis, 24*(2), 81-112.

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher, 38*(3), 181-199.

Draper, S. W. & Brown, M. I. (2004). Increasing interactivity in lectures using an electronic voting system. *Journal of Computer Assisted Learning, 20*(2), 81-94.

Pearson Education. (2017). edTPA. Retrieved from https://edtpa.com.

Fagen, A.P., Crouch, C.H., & Mazur, E. (2002). Peer instruction: Results from a range of classrooms. *The Physics Teacher*, 40(4), 206-209.

Fies, C., & Marshall, J. (2006). Classroom response systems: A review of the literature. *Journal of Science Education and Technology, 15*(1), 101-109.

Fraenkel, J. R. & Wallen, N. E. (2006). *How to design and evaluate research in education* (6th ed.). Boston, MA: McGraw-Hill.

GaDOE (2011). *Class Keys: Classroom analysis of state standards*. Retrieved on 6 February 2017 from https://www.gadoe.org/School-Improvement/Teacher-and-Leader-Effectiveness.

Garet, M. S., Porter, A. C., Desimone, L. M., Birman, B., & Yoon, K. S. (2001). What makes professional development effective? Analysis of a national sample of teachers. *American Educational Research Journal, 38*(3), 915-945.

Glesne, C. (2006). *Becoming qualitative researchers: An introduction* (3rd ed.). Boston, MA: Pearson Education.

Gordon, J. (1991). Measuring the "goodness" of training. *Training*, 19–25.

Guskey, T. R. (1998). The age of our accountability: Evaluation must become an integral part of staff development. *Journal of Staff Development, 19*(4), 36-44.

Guskey, T. R. (2000). *Evaluating professional development.* Thousand Oaks, CA: Corwin.

Guskey, T. R. (2002). Does it make a difference? Evaluating Professional Development. *Educational Leadership, 59*(6), 45-51.

Guskey, T. R. (2003). What makes professional development effective? *Phi Delta Kappan, 84*(10), 748-750.

Guskey, T. R. & Yoon, K. S. (2009). What works in professional development? *Phi Delta Kappan, 90*(7), 495-500.

Hew, K. F. & Brush, T. (2007). Integrating technology into K-12 teaching and learning: Current knowledge gaps and recommendations for future research. *Educational Technology Research & Development, 55*(3), 223-252.

Hill, H. (2007). Learning in the teaching workforce. *Excellence in the Classroom, 17*(1), 111-127. Retrieved on 6 February 2017 from http://www.futureofchildren.org/futureofchildren/publications/journals/.

Hill, H. (2009). Fixing teacher professional development. *Phi Delta Kappan, 90*(7), 470-476.

Hirsh, S. & Killion, J. (2009). When educators learn, students learn. *Phi Delta Kappan, 90(*7), 464-469.

Hughes, J. E. & Ooms, A. (2004). Content-focused technology inquiry groups: Preparing urban teachers to integrate technology to transform student learning. *Journal of Research on Technology in Education, 36*(4), 397-411.

Kahoot! (2017). Kahoot! [Mobile application software]. Retrieved on 6 February 2017 from https://getkahoot.com/.

Killion, J. & Harrison, C. (2006). *Taking the lead: New roles for teachers and school-based coaches.* Oxford, OH: National Staff Development Council.

Knowles, M. S., Holton, E. F., & Swanson, R. A. (1998). *The adult learner*. Houston, TX: Gulf Publishing.

Lee, H. J. (2005). Developing a professional development program model based on teachers' needs. *The Professional Educator, 27*(1), 39-49.

Mazur, E. (1997). *Peer instruction: A user's manual.* Upper Saddle River, NJ: Prentice Hall.

Mouza, C. (2003). Learning to teach with new technology: Implications for professional development. *Journal of Research on Technology in Education, 35*(2), 272-289.

Nearpod. (2017). Nearpod. [Mobile application software]. Retrieved on 6 February 2017 from http://www.nearpod.com/.

North Carolina State Board of Education. (2007). *Rubric for evaluating North Carolina teachers*. Retrieved on 6 February 2017 from http://www.necollaborative.org/docs/ncteacherevaluationrubric.pdf.

Patton, M. Q. (1987). *How to use qualitative methods in evaluation.* Newbury Park, CA: Sage Publications, Inc.

Penuel, W. R., Boscardin, C. K., Masyn, K., Crawford, V. M. (2007). Teaching with student response systems in elementary and secondary education settings: A survey study. *Education Technology Research & Development 55(*4), 315-346.

Polly, D., Rodgers, E., & Little, M. (2015). Leveraging interactive clickers as a tool for formative assessment. In D. Polly (Ed.), *Cases on Technology Integration in Mathematics Education* (pp. 330-350). Hershey, PA: Information Science Reference. doi:10.4018/978-1-4666-6497-5.ch016

Rebecca, C. Y., Andrea, K. S. M., & Jermaine, L. S. S. (2014). Assessment for Learning (AfL) Approaches–How we know that they know. *Proceedings of the 40th Annual International Association for Educational Assessment Conference.* Singapore, China: IAEA. Retrieved from http://www.iaea.info/documents/paper_226dc2beb.pdf.

Socrative. (2017). Socrative. [Mobile application software]. Retrieved from http://socrative.com/.

Sparks, D. (2002). *Designing powerful professional development for teachers and principals.* Retrieved from http://files.eric.ed.gov/fulltext/ED470239.pdf.

Walsh, P. D. (2014). Taking advantage of mobile devices: Using Socrative in the classroom. *Journal of Teaching and Learning with Technology. 3*(1), 99-101. Retrieved on 6 February 2017 from http://jotlt.indiana.edu/article/view/5016.

Wang, A. I. (2015). The wear out effect of a game-based student response system. *Computers in Education. 82*, 217-227. Retrieved on 6 February 2017 from http://www.sciencedirect.com/science/article/pii/S0360131514002516.

Wayne, A. J., Yoon, K. S., Zhu, P., Cronen, S., & Garet, M. S. (2008). Experimenting with teacher professional development: Motives and methods. *Educational Researcher, 37*(8), 469-479.

Williams, H. & Kingham, M. (2003). Infusion of technology into the curriculum. *Journal of Instructional Psychology, 30*(3), 178-184.

Correspondence: Julia S. Fuller, Assistant Professor, Department of Instructional Technology, Bagwell College of Education, Kennesaw State University, Kennesaw, Georgia, USA.