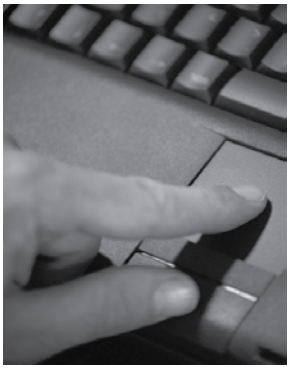

Teaching Formative Assessment Strategies to Preservice Teachers: Exploring the Use of Handheld Computing to Facilitate the Action Research Process

Kristin Redington Bennett and Ann C. Cunningham

Abstract

Appropriate classroom assessment now tends to utilize formative measures with greater frequency, especially in the early grades and with learner groups at risk of not passing state-mandated standardized tests. Within the authentic context of an action research project, teacher candidates were given handheld computers equipped with data-collection software to assess the effectiveness of tutoring sessions with students identified with special needs. The data was collected and reviewed weekly as formative assessment and was also analyzed over time for performance trends. The goal was to explore whether the introduction of handheld data collection tools and new pedagogical practices embedded in an action research project is a feasible expectation for novice teachers. Results from postexperience questionnaires and analysis of recurrent themes in written reflections indicate that the teacher candidates valued the action research and formative assessment process. Although the hardware created a variety of challenges to data collection, all participants recognized the value of the handheld computer for classroom-based formative assessment. This study is the first step in a long-term research study on the efficacy of handheld tools to support formative assessment in the elementary classroom. (Keywords: formative assessment, action research, preservice teachers, handheld computers, one-to-one computing)

Introduction

The effectiveness of any instructional program often turns in part on the use of effective assessment materials and tools. Although teachers strive to create meaningful learning situations involving the "whole child," they often rely on summative, standardized assessment strategies, which are a poor fit to instructional programs (Means, Penuel, and Quellmalz, 2001). Improving classroom assessment practices has proven to be challenging. Assessment, especially formative assessment, is given little attention in classrooms, where teachers rarely have adequate time to plan or implement assessment activities in a methodical manner or to learn new strategies for assessment from peers or experts (Black & William, 1998; Darling-Hammond, Ancess, & Falk, 1995). Further, research suggests that even those teachers who do engage in some form of formative assessment are more apt to look at individual behaviors rather than systematically assessing student learning (Mandinach et al, 2006; Mandinach et al, 2005; Confrey & Makar, 2002, 2005)

Student performance expectations established by state education agencies in response to No Child Left Behind (NCLB) legislation provide an impetus for a greater focus on formative assessment in the classroom. Assessment must be viewed as an integral part of instruction because it "not only provides information about learning, it drives learning" (Lewis, 2006, p. 29). Well-designed formative assessment instruments that capture performance data on individual students are a vital component of student success on formal benchmark assessments, and interim assessment is necessary to diagnose student needs for additional instruction (Lewis, 2006, p. 17). What is needed is a method that teachers can easily employ in the classroom to make formative assessment timely, "provide quality feedback, strengthen teaching and learning, and involve students in accountability" (Lewis, 2006, p. 30). Although experts in the field of psychometrics report that this type of assessment practice is valuable, they also admit that it is not currently being implemented in K–12 classrooms. The Center for Research on Evaluation, Standards, and Student Testing (CRESST) Co-Director Eva Herman states, "These types of assessments are often nonexistent in curriculum materials, in teachers' repertoires, and not often found in benchmark tests. According to Lewis (2006), teachers do not have time to devise these types of assessments on their own (p. 29). A need exists to increase knowledge and understanding of formative assessment techniques in teacher preparation programs.

This paper describes the results of a preliminary exploration of the integration of an action research model that emphasizes the role of formative assessment using data collection with handheld computers. The goal is to scaffold the development of sound instructional decision-making practices by teacher candidates during field experiences in elementary classrooms. The purpose of this study was to determine the efficacy of such a model with novice teachers, and the focus of this paper is the use of a handheld computing device to facilitate collection of formative assessment data in the field.

The study explores the following questions:

1. Do teacher candidates find handheld computers useful for conducting regular formative assessment?
2. Do preservice teachers recognize the value of formative assessment as a method for improving instructional practice?

Literature Review

Action Research

This research project is framed within the contexts of action research and situated learning. Herrington and Oliver (1999) compiled a list of "nine characteristics of a situated learning framework, namely: an authentic context; complex authentic activities; multiple perspectives; expert performances; coaching and scaffolding; opportunities for collaboration, reflection, and articulation; and authentic assessment" (p. 402).

The framework provided by that of situated learning complements the methodological framework of action research. Cohen and Manion (1989) suggest that action research can be difficult to define; however, they also assert that the research literature reveals this method to have tangible features:

> Action research is situational—it is concerned with diagnosing a problem in a specific context and attempting to solve it in that context. It is usually collaborative—teams

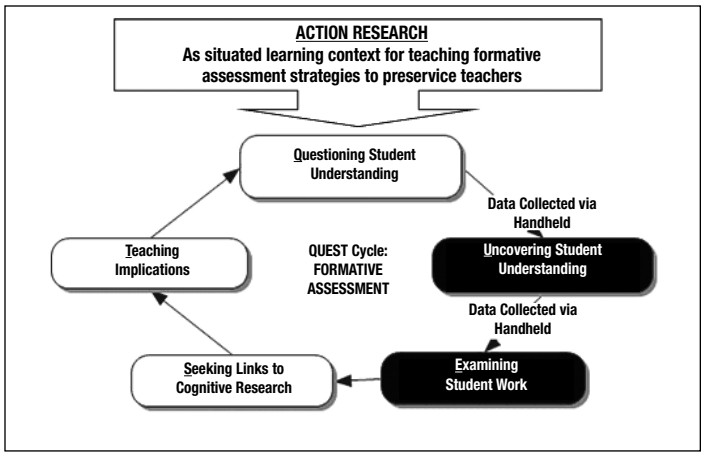

Figure 1: Model of Action Research Process Supported by Handheld Data Collection.

> of researchers and practitioners work together on a project; it is participatory—team members themselves take part directly or indirectly in implementing the research; and it is self-evaluative—modifications are continuously evaluated within the ongoing situation (p. 217).
>
> Action research is often represented as a four-phase cyclical process where a plan is formulated, that plan is acted upon, the outcomes are observed, and reflection is undertaken to understand the processes, strengths, and weaknesses of the effort. The conscious analysis or reflection stage of action research distinguishes it from the casual "plan, act, sense, and re-plan" cycle by which we operate in everyday life (Tripp, 1990).

Recent studies have asserted that undergoing action research as part of their education programs can benefit undergraduate preservice teachers (Price, 2001; Rock & Levin, 2002). As the benefits of action research being demonstrated in these studies and other studies (Burnaford and Hobson, 1995; Johnson and Button, 2000; Sax and Fisher, 2001) of graduate-level teacher education students, Fueyo and Koorland (1997) have called for action research to be included as part of preservice education programs. Using action research strengthens professional development opportunities (Mills, 2003) and has strong relevance for preservice and inservice teachers, especially as related to increasing student performance through reflective practice enriched by the collection of data that facilitates a deeper understanding of student performance.

Formative Assessment

Formative assessment in and of itself is a form of action research. Whereas action research is generally done in a learning context by teachers as professional development, formative assessment is done in a *teaching* context and is a natural component of action research. In *Mathematics Assessment Probes*, Rose et al. (2007, p. 14) suggest that formative assessment should include working through a QUEST cycle (see Figure 1), which includes:

- Questioning student understanding of a particular concept
- Uncovering understanding and misunderstandings using a problem
- Examining student work
- Seeking links to cognitive research to drive next steps in instruction
- Teaching implications based on findings and determining impact on learning by asking an additional question.

This systematic cyclical approach eschews the conventional single-purpose, cumulative, high-stakes accountability testing in favor of data-driven instructional decisions based on assessment for learning. As Stiggins (2005) suggests, one reason for the recent resurgence of interest in formative assessment has been educators' realization that once-a-year summative standardized testing doesn't happen frequently enough to affect specific day-to-day, week-to-week, or even month-to-month instructional decisions. Further, such testing fails to provide a sufficiently detailed picture of student learning to enable teachers to identify ways to help individual students. As teachers are recognizing the value of data-driven instructional models, a natural next step is to establish systematic methods and applications for collecting and analyzing this data in a timely, day-to-day manner.

Handhelds

Handheld computers offer the opportunity to facilitate teachers' implementation of continuous, authentic, and reflective assessment in the classroom. Sheilds and Poftak (2002) suggest that "handhelds offer portability while at the same time packing enough computing power for writing, crunching numbers, and surfing the Web. . . . infrared beaming offer opportunities for real-time student collaboration, and with pricing near half the cost of a laptop, the days of one computer for every student may be tantalizingly close at hand" (p. 24). Because of their portability, handheld computers ease the data-gathering process because of their unobtrusiveness and ease the aggregation of data because of their technological features. Many researchers have heralded the myriad potential uses of handhelds in field investigations (Hsi 2000; Soloway et al., 1999). Ongoing, in-the-moment, formative assessment made easier by the portability of handhelds means that assessment can occur in any location at any phase of the learning process. Further, their affordability means that they are a feasible option for widespread use in our schools.

Developments in pedagogy and learning science have moved toward processes that engage a more active learner using constructivist models, with learners making their own decisions that match their cognitive needs. Involving preservice teachers in the learning of formative assessment processes using handhelds devices certainly lends to an active, constructivist learning experience.

Research Methods

To determine the value of handheld computing devices for the collection of formative assessment data in elementary classrooms, the author implemented an action research project with two groups of preservice teachers at a small, private university in the southeast United States. The handheld computing tools were used iPAQs owned by the university and were available at no charge to the student participants, the data-collection software was also a university creation that was available for free, and on-site technical support was readily available. Despite the age of the equipment, it was determined that these free tools would be appropriate for investigation of the application of a handheld for data collection in the field. The researchers were aware of the future direction of handheld computing devices and wanted to explore the efficacy of such tools within a complex pedagogical model prior to committing to the extensive costs of state-of-the-art handheld computing solutions. Therefore, this paper focuses on questions relating to the use of a handheld computing device to facilitate formative assessment data collection and to scaffold the development of data-driven instructional practice habits in preservice teachers.

Answering the questions regarding the utility and teacher-perceived effectiveness of using handhelds to facilitate the teaching and learning of formative assessment practices was done through a complex model that embeds on a dual level the QUEST (Rose et al., 2007) diagnostic strategy of formative assessment within the action research process. The following discussion of the research process will describe this process of situated learning for preservice teachers.

Data Sources and Analysis

The participants were all teacher candidates in the final semester of their elementary education program. Data was collected with two groups of participants with similar backgrounds during the spring semester of two consecutive years. These participants were a convenience sample (Group 1 n=17, Group 2 n=15) who were all enrolled in a required course, "Teaching Children with Special Needs," the final class in the elementary education course sequence. This course includes a field experience that requires the participants to be in a local elementary school tutoring the same student every week. All participants successfully completed their student teaching experience in the prior semester, and the participants all had extensive technology experience in part due to the ubiquitous resources of a one-to-one laptop university and through their teacher education coursework, which includes a required technology course. Several of the participants had prior experience using handheld computing devices, but not for collection and analysis of data on student performance.

The use of handheld computers to facilitate data collection was made for several reasons; one primary criterion was related to the availability of the hardware and software for no cost to the students. The researchers' knowledge of the future direction of handheld tools encouraged the exploration at the beginning of the research project even though the tools were not state of the art. The decision was made to use older hardware and study the efficacy or perceived efficacy of handheld computing for data collection and determine whether novice teachers recognized the value of formative assessment within an authentic teaching context. The integration of a data-collection tool that allows users to create surveys on their laptops and transfer the survey easily to the handheld and the results easily to the computer was an innovation important for future teachers to experience, especially within an authentic context.

The researchers issued both groups of participants their own iPAQ handheld devices with associated accessories and portable keyboards. They received training on the handheld through a collaborative training session designed by members of the Information Systems Department and faculty members from the Department of Education. The first training session included an introduction to the handhelds and their general features, as well as features specifically designed for students at the university. The first group of participants was given time to experience (play with) the handhelds over a period of two weeks before being introduced to the field data-collection software, DataInHand (http://datainhand.wfu.edu), a simple survey-creation software designed for handheld devices. DataInHand was developed by the research and development team in the Information Systems division at the university. The features of this software include a simple interface that permits survey development on the computer (Likert scale, yes/no, short-response questions) and simple transfer and retrieval of completed surveys to and from the handheld device. Results can be reported in HTML, Microsoft Word, and Microsoft Excel formats.

Process and Implementation: Year One

To more strongly situate the action research process, we asked participants to select one student identified with special needs from their student teaching experience to tutor one on one for 2 hours each week. We asked participants to work with school personnel to identify learning challenges and establish growth goals for the chosen student, and we guided them to address "the whole child" in their tutoring and include assessment items that related to affect and behavior in addition to learning goals. After conducting the needs assessment and identifying learning goals for the tutee, we asked the participants to design an assessment instrument to measure the effectiveness of their instructional interactions with the student as well as any affective or cognitive changes they noted during their sessions. The researchers provided training on the data-collection software that included coverage of the software features, survey creation, data collection, and transfer of data-collection instruments and data between the handheld and the laptop. The researchers involved with this project as well as support personnel from the university's Information Systems division were made available to answer questions about hardware or software during this time, but the content of the instrument was largely determined by the participants, as they knew the students they would be tutoring from the previous semester as student teachers. The researchers then asked the participants to perform several trial runs of the instrument with fictional information to practice the process of downloading, uploading, and reporting in an effort to promote efficient data collection and storage. After reflection on initial data collection experiences and discussion of the results, the participants decided to create an instrument that was consistent across all tutoring situations and that allowed individuals to add additional questions specific to his/her child's special needs. Once the questions were determined, all participants entered it into the DataInHand program while in the university classroom. As part of their action research plan, the participants agreed to use this instrument in the field for 2 weeks and then come together to reflect on and modify either the instrument or the process.

After the 2-week trial period, the participants determined that the instrument needed modification to include fewer open-ended questions. At this time, the participants also shared their individually created "additional questions'" which led several participants to modify their instruments to include questions particularly relevant to their individual tutees. The participants then utilized this modified instrument for the remainder of the semester, repeating the administration and data collection via handheld computer on a weekly basis. Class sessions included guided reflection on the process of data collection and analysis as well as discussion of the efficacy of the handheld computers.

Process and Implementation: Year Two

The data collected from the first year of the study lead to small but significant modifications in the second year of the study. Review of the participants' project results, postsurveys, and anecdotal evidence identified several significant findings that affected the design of the second year of the study. These included:

- Hardware problems often made the technology burdensome rather than helpful.
- Assessment instruments need to be short, and questions must permit input via the stylus rather than the keyboard.
- Although open-ended questions yield rich data, they make field-based data collection challenging.

The researchers determined that the early distribution and training on the handhelds at the end of the fall semester was necessary to increase the time for participants to familiarize themselves with the hardware and reduce the frequency of hardware problems. Additionally, the researchers scheduled more opportunities for survey design and modification as well as hardware and software support during the regular class sessions. These sessions were added based on experience gained during the first year of the study and were designed to help overcome hardware and software barriers and to provide opportunities for group reflection on the data-collection process and redesign of surveys.

Another significant change included the placement of all participants in a new elementary school partnership. None of the participants completed their student teaching in this school, and the classroom for this field placement was entirely comprised of students identified with special needs.

The change in setting, as well as analysis of the data from year one, led to several changes in the instrument content, creation, and data collection.

Table 1: Measures of Central Tendency for Responses to Postexperience Questionnaires of Teacher Candidates Regarding Formative Assessment and Use of Handhelds to Support Field-Based Data Collection and Analysis

Questions	2006		2007	
	Mean	Mode	Mean	Mode
1. The handheld is a useful tool for collecting data in the field.	2.07	3	2.42	2
2. The assessment instrument made it easier to capture data in the field.	2.14	3	2.47	2
3. The handheld facilitated completion of course assignments.	2.21	3	2.42	2
4. The handheld and assessment instrument allowed me to collect and process field observations in a timely manner	2.21	2	2.05	3
5. Using a handheld device and a consistent data collection tool facilitated data analysis.	2.35	3	2.36	3
6. Using these tools to collect data in the field was worthwhile.	2.0	2	2.11	2
7. My understanding of how to use technology for formative assessment has been enhanced by this experience.	2.64	3	2.52	3

Participants were provided with an exemplar instrument adapted from the year-one study that included fewer open-ended questions and more Likert-type items. The instrument items (see Appendix A) included more questions on the affect of both the tutor and the tutee during the tutoring sessions. Participants were still given the option to include questions that specifically related to their tutees. The feedback on challenges associated with keyboard-based data entry compelled the researchers to encourage question design based on state performance standards and the state assessment scale, which could be facilitated by Likert-type questions and removed the need to enter data with a keyboard. The researchers suggested the possibility of including state Standard Course of Study objectives as assessment items but left the final decision up to the participants.

Findings

This 2-year study generated a wealth of data from the participants regarding preservice teachers' awareness of how formative assessment effects instructional practice and the value of handheld tools for collecting formative assessment data. Each participant completed a postexperience questionnaire consisting of Likert-type and open-ended response questions that asked them to describe their attitudes about the use and value of the handheld device for collecting formative assessment data and completing tasks that require field-based data collection.

The data garnered from the participants' data collection in the field provided information on the weekly successes, setbacks, and other important details about both the participants and their students and was used to guide decision making about tutoring as well as to inform their written reflections about the action research process and tutoring experience.

Do Teacher Candidates Find Handheld Computers Useful for Conducting Regular Formative Assessment?

To determine teacher candidates' attitudes toward using handhelds for formative assessment, the researchers asked seven postexperience questions that required the participants to rate their response on a scale from 1 to 4. Table 1 shows the questions from the postexperience questionnaire for both years of the study (2006 and 2007) and provides the means and modes for responses from each group on a 4-point scale as follows: 1=strongly disagree, 2=disagree, 3=agree, 4 =strongly agree.

Responses from participants in both groups were analyzed in measures of central tendency to show more complete data for each small group. Based on the mean, participants in the 2007 study group agree more often than participants in the 2006 study group that the handheld was a useful tool for collecting data in the field. In response to question 2, participants in the 2007 group agree more often that the software made it easier to capture data in the field than respondents in the 2006 group. In response to question 3, members of the 2007 group agree more often that the handheld facilitated completion of course assignments than members of the 2006 group. Although the means for both groups' responses tend more toward disagreement to question 4, the mean for the 2006 group is higher and the mode indicates that more members of the 2007 group agreed that the tools facilitated processing field observations in a timely manner. In response to question 5, the mode indicates that the majority of respondents in both groups agreed that when used consistently, the tools facilitated data analysis. However, their responses to question 6 indicate that both groups did not agree that using the tools to collect data in the field was worthwhile. Both groups were consistent in their responses to question 7, and the mode reveals that their understanding of technology use to collect formative assessment data was enhanced by this experience. Both measures of central tendency were higher for both groups on this question.

Figure 2 presents a visual representation of the comparison of the means for the responses from both the 2006 study group and the 2007 study group. Figure 3 presents a visual representation of the comparison of the modes for the responses from both groups.

To further cull out the idiosyncrasies of the study groups' mixed responses to the postexperience questions, the researchers looked to candidates' responses to the following two open-ended questions regarding suggested changes:

1. What would you recommend we change before implementing handheld computers and DataInHand for this academic purpose in the future?
2. Please share any comments about your experience with field observations that would help us improve training, data collection, or data analysis in the future.

Content analysis of the combined responses mimics some of the mixed reactions found in the quantitative indices. However, the qualitative data also reveals that candidates recognized the potential benefits for using the handhelds devices and were able to separate the problems with the hardware, the problems with the software, and the actual context for learning formative assessment. The coded data indicates that the most suggested change surrounded the candidates' frustration with the hardware. Secondarily, candidates said that using the right software and instrumentation were vital aspects of a successful experience. Finally, despite the hardware and software issues, the candidates were optimistic about the technology and potential usefulness of using handheld devices to collect data. Table 2 provides exemplar quotes from each theme that emerged during content analysis.

Although there were mixed feelings about the use of the iPAQ as a means for ongoing field-based data collection, the participants were able to grasp the value of intentionally recording data to make informed instructional decisions, which was an important growth experience for novice teachers.

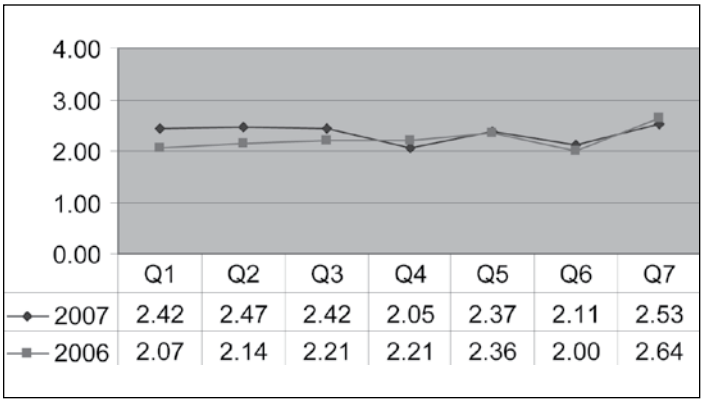

Figure 2: Comparison of Means for Both Study Groups' Responses to Post-experience Questionnaire.

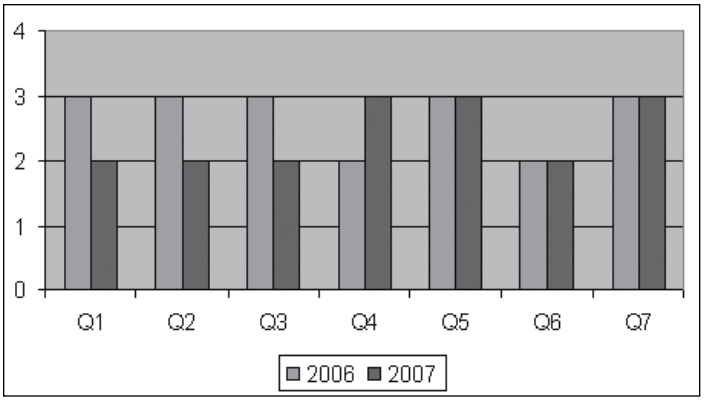

Figure 3: Comparison of Modes for Both Study Groups' Responses to Post-experience Questionnaire.

Do Preservice Teachers Recognize the Value of Formative Assessment as a Method for Improving Instructional Practice?

By and large, preservice teachers recognized the value of formative assessment as a method for improving instructional practice. Analysis of the responses to the open-ended question, "How did the data inform your sessions on a day-to-day basis?" indicate preservice teachers' discovery awareness of the purpose for formative assessment. The following selected quotes evidence this discovery and appreciation:

> I saw correlations between his mood and focus level, and the use of the survey caused me to look at other factors that played into focus and progress. The assessment format definitely helped me to know the correct way to conduct and improve my tutoring sessions. Through using the survey, my awareness of student progress and the need to make adaptations became especially clear when I looked at the data on the Excel spreadsheet. I am not sure that without the reflection my sessions would have had gradual improvement over time.

> For instance, Student X struggled with complex operations and fractions. Seeing this documented continuously reminded me to spend extra time in these areas. This was the most valuable part of having the written survey results. As well, when days didn't go well, I could look back and see that there were days that went well, and that was encouraging (and I could see what worked that day).

> During the first half of the semester, I used the original tutoring survey yet felt that I was not evaluating anything directly pertaining to my sessions with Student Y. I later created a new survey to better track Student Y's progress with measures of motivation, mood, and distractibility. I was better able to assess my effectiveness with this survey.

Discussion

Quantitative indices from participants about the appropriateness of the hardware and software for data collection in the field proved to be consistent across both study groups despite modifications implemented in the second year. Analysis of qualitative data also revealed that the iPAQ was not the most reliable method for capturing and storing field-based data. Several factors may have contributed to the less than positive responses from the participants regarding classroom-based data collection with handheld computers. Primarily, problems with the hardware provided challenges for the majority of the participants. Unreliable hardware (i.e., keyboards not connecting, failure to hold a charge) was most likely associated with the capabilities and age of the handheld computing tools. Another contributing factor was the prior knowledge of handheld computing tool use. Most of the participants experience with handheld devices was limited to cell phones, and only 10 of the 31 participants had ever used handheld computers before. Of the 31 participants in both years of the study, only one indicated using the cell phone to connect to the Internet. This lack of experience with connecting handhelds to computers to transfer data could affect maintenance of handheld computers for retaining files. Loss of data was experienced by more than one participant because the handhelds lose all of the stored data when they lose charge.

Unfamiliarity with software used to create the assessment instruments was also a potential reason for negative responses to questions regarding the appropriateness of the hardware and software tools for classroom-based formative assessment. Accurate and efficient data collection might have been a source of stress for the participants because the results were to be used to complete course assignments.

Based on the quantitative and qualitative analysis of participant responses, the researchers decided that further integration of handheld data collection would require more modern and reliable tools.

Recognition of the value of technology to support formative assessment was consistent. Even though the hardware was determined to be a drawback, the process of situating formative assessment within a field-based action research process scaffolds candidates' understanding of the value of technology for formative assessment. Participants in both groups agreed that their understanding of how technology can be used for formative assessment was enhanced by this experience.

Open-ended responses and reflection about the value of data-collection tools for formative assessment were, in general, very positive. The participants actively sought to reflect upon and transform their practices as well as their data-collection instruments based on trends they noticed in their work with tutees.

Implications

Although the quantitative responses indicate a generally neutral attitude toward the use of handhelds for formative assessment, the qualitative responses indicate that the process of data collection did help the participants recognize the value of ongoing formative data collection. The lack of more vehement negative responses about the use of the iPAQ as a data-collection instrument is surprising in light of the chronic hardware challenges faced by both study groups. A variety of negative conditions unrelated to action research, formative assessment, survey creation, or data

Table 2: Content Analysis Themes Regarding Usefulness of Handheld for Collection of Formative Assessment Data

Hardware Deficiencies	"I had a really hard time keeping the IPAQ charged. It was either over-charged and lost it's data or the battery died when it wasn't charged enough. Maybe if I was using it on regular basis, rather than just for this class I wouldn't have had this issue??"
	"I began by entering the information as soon as I was done by answering the survey questions. I lost everything during spring break because I didn't charge it. Instead of re-creating the survey, I just used Excel. I liked the layout better anyway."
	"The IPAQ is a great incorporation of technology, but the negatives far outweigh the positives. The negatives were that the IPAQ died and the information would be lost (if not charged, if charged too much)."
Software & Instrumentation Changes	"Because the IPAQ crashed, I created an Excel spreadsheet to track progress. The trends from the spreadsheet show an increase in the enjoyment of reading, and a decrease in verbal stimulation…Using the general survey too was too general, I liked creating one that was specific to my tutee."
	"I like the Data-In-Hand software and it's capabilities; however, data entry for me was too tedious because of the open-ended questions I made. Entering long answers interrupted instructional time."
	"I would have been more successful if I had used a survey that measured more specific parts of progress made. The specific questions I did have were very helpful. Maybe if we had more training in how to write our own surveys that would help."
Generally Useful	"With some changes, the handheld could be very beneficial. The use of technology can speed along processes in the classroom – especially assessment! We were able to quickly and easily input data on our student. I can see how handhelds would be great because they are small and easily accessible."
	"The additional comments section was the most helpful (using the handheld survey tool). This is where I would record things that I wanted to remember to do next time, or things that I wanted to remember about the current session. I liked having these details."
	"I appreciated it though because it was a great thing to utilize to get myself thinking about the overall experience with Student X. I think I would recommend some future product that could also readily be incorporated into everyday life. If this were the case, it would also be useful to organize thoughts, lessons, activities, along with collecting data on student progress."

collection must be considered as contributing to the less than enthusiastic responses from the participants about the handheld technology. Positive results that weren't captured in the responses were the ease of use of the survey-creation tool and the simplicity of capturing and exporting results of data collection to the computer. The respondents' acknowledgment that their understanding of classroom technology use was enhanced by this experience is also positive and encourages further research in this area. Situating action research within a one-to-one tutoring experience provides the scaffolding necessary to promote the development of formative assessment skills and dispositions.

Because of the limitations of the handheld computers used for this project and the advent of more reliable handheld technologies, future studies should utilize Smartphone technology and, as possible, integrate it in coursework for more than one semester and in more intensive and regular field experiences. Preservice teachers should be comfortable with the devices to remove the stress of participating in graded action research projects in field experiences, or research should be limited to participants who are comfortable with the tools. It is more likely that candidates will enter education courses with more prior experience due entirely to the advancement of cell phone technology. Formative assessment systems that generate information about student achievement are critical to ensuring the success of students in PK–12 classrooms, and field-based action research provides a context to facilitate this type of instruction. Handheld computing devices are inexpensive, multipurpose, and relatively ubiquitous. Future teachers need to learn how to use these tools effectively in their 21st-century classrooms to measure, analyze, and communicate student progress to improve learning as a whole.

Teacher educators, preservice and inservice, should recognize that preparing teachers to conduct ongoing formative assessment that informs instructional decision making is a critical part of instructional design. Embedding such experiences within an action research model and connecting them to field-based data collection is clearly a viable method for scaffolding the development of skills and attitudes regarding formative assessment techniques and benefits. This model is theoretically sound and viable for teachers of all experience levels.

References

Black, P., & William, D. (1998). Assessment and classroom learning. *Assessment in Education, 5*(1), 7–74.

Burnaford, G., & Hobson, D. (1995). Beginning with the group: Collaboration as the cornerstone of graduate teacher education. *Action in Teacher Education, 17*, 67–75.

Cohen, L., & Manion, L. (1989). *Research methods in education, 3rd edition.* New York: Routledge.

Confrey, J., & Makar, K. (2002). Developing secondary teachers' statistical inquiry through immersion in high-stakes accountability data. In D. Mewborn, P. Sztajn, & D. White (Eds.), *Proceedings of the twenty-fourth annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education PME-NA24* (pp. 1267–1279), *3*, Athens, GA.

Confrey, J., & Makar, K. (2005). Critiquing and improving data use from high stakes tests: Understanding variation and distribution in relation to equity using dynamic statistics software. In C. Dede, J. P. Honan, & l. C. Peters (Eds.), *Scaling up success: Lessons learned from technology-based educational improvement* (pp. 198–226). San Francisco: Jossey-Bass.

Darling-Hammond, L., Ancess, J., & Falk, B. (1995). *Authentic assessment in action: Studies of schools and students at work*. New York: Teachers College Press.

DataInHand [Computer software]. (2004). Winston-Salem, North Carolina: Wake Forest University Information Systems Research and Development Group.

Fueyo, V., & Koorland, M. A. (1997). Teacher as researcher: A synonym for professionalism. *Journal of Teacher Education, 48,* 336–344.

Herrington, J., & Oliver, R. (1999). Using situated learning and multimedia to investigate higher order thinking. *Journal of Educational Multimedia and Hypermedia, 8*(4), 401–421.

Hsi, S. (2000, April). *Using handheld technologies to connect Web-based learning to outdoor investigations.* Paper presented at the National Association for Research in Science Teaching Annual Meeting.

Johnson, M., & Button, K. (2000). Connecting graduate education in language arts with teaching contexts: The power of action research. *English Education, 32*(2), 107–126.

Lewis, Anne (2006). *Celebrating 20 years of research on educational assessment: Proceedings of the 2005 CRESST Conference* (Technical Report No. 698). Los Angeles, CA: Center for the Study of Evaluation & National Center for Research on Evaluation, Standards, and Student Testing Conference. Retrieved on February 11, 2009, from http://www.cse.ucla.edu/products/reports_set.htm

Mandinach, E. B., Honey, M., & Light, D. (2006, April). *A theoretical framework for data-driven decision making.* Paper presented at the annual meeting of the American Educational Research Association, San Francisco, CA. Retrieved on February 11, 2009, from http://eric.ed.gov/ERICWebPortal/custom/portlets/recordDetails/detailmini.jsp?_nfpb=true&_&ERICExtSearch_SearchValue_0=ED494275&ERICExtSearch_SearchType_0=no&accno=ED494275

Mandinach, E. B., Honey, M., Light, D., Heinze, C., & Nudell, H. (2005, April). *Data-driven instructional decision making using technology-based tools.* Paper presented at the meeting of the American Educational Research Association, Montreal, Canada.

Means, B., Penuel, W. R., & Quellmalz, E. (2001). Developing assessments for tomorrow's classrooms. In W. Heinecke & L. Blasi (Eds.), *Research Methods for Educational Technology.* (Vol. Volume One: Methods of Evaluating Educational Technology.). Greenwich, CT: Information Age Press.

Mills, G. (2006) *Action research. A guide for the teacher researcher.* (3rd ed.). Upper Saddle River, NJ: Merrill Prentice Hall.

Price, J. N. (2001). Action research, pedagogy and change: The transformative potential of action research in pre-service teacher education. *Journal of Curriculum Studies, 33*(1), 43–74.

Rock, T. C., & Levin, B. B. (2002). Collaborative action research projects: Enhancing preservice teacher development in professional development schools. *Teacher Education Quarterly, 29* (1), 7–21.

Rose, C. M., Minton, L., & Arline, C. (2007). *Uncovering student thinking in mathematics: 25 formative assessment probes.* Thousand Oaks, CA: Corwin Press.

Sax, C., & Fisher, D. (2001). Using qualitative action research to effect change: Implications for professional education. *Teacher Education Quarterly, 28* (2), 71–80.

Shields & Poftak (2002). A report card on handheld computing. *Technology & Learning*, February, 24–36.

Soloway, E., Grant, W., Tinker, R., Roschelle, J., Mills, M., Resnick, M., et al. (1999). Science in the palm of their hands. *Communications of the ACM, 42*, 21–26.

Stiggins, R. (2005) From formative assessment to assessment for learning: A path to success in standards-based schools. *Phi Delta Kappan, 87*, 04, 324–328.

Tripp, D. (1990). Socially critical action research. *Theory in Practice, 29*(3), 158–166.

Kristin Redington Bennett is an assistant professor in the Department of Education at Wake Forest University. Her primary role is the preparation of undergraduate elementary teacher candidates for teaching and leading in 21st-century schools. Her teaching and research interests revolve around technology-supported action research as pedagogy and formative assessment.

Kristin Redington Bennett, PhD
Department of Education
Wake Forest University
PO Box 7266
Winston-Salem, NC 27109
E-mail: bennetkr@wfu.edu

Ann C. Cunningham is an associate professor in the Department of Education at Wake Forest University. She holds a PhD in instruction and teacher education from the University of South Carolina adn specializesin cross-disciplinary technology-enhanced instructional design. Her education adn scholarly interests include teacher leadership, electronic portfolios, technology integration, and assessment.

Ann C. Cunningham, PhD
Department of Education
Wake Forest University
Winston-Salem, NC 27109
E-mail: cunninac@wfu.edu

Appendix

Postexperience Survey

Questions regarding use and value of handheld tools for field-based data collection:

1. The handheld is a useful tool for collecting data in the field.
2. DataInHand software made it easier to capture data in the field.
3. The handheld and DataInHand facilitated completion of course assignments.
4. The handheld and DataInHand allowed me to collect and process field observations in a timely manner.
5. Using a handheld device and a consistent data-collection tool facilitated data analysis.
6. Using these tools to collect data in the field was worthwhile.
7. My understanding of how to use technology in the classroom has been enhanced by this experience.