PROBEWARE INTEGRATION IN THE SCIENCE CLASSROOM: THE IMPACT OF A SIX-HOUR PROFESSIONAL DEVELOPMENT WORKSHOP THAT COMBINES TECHNICAL INSTRUCTION WITH IMPLEMENTATION PLANNING

by

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STATEMENT OF PERMISSION TO USE

In presenting this professional paper in partial fulfillment of the requirements for a master's degree at Montana State University, I agree that the MSSE Program shall make it available to borrowers under rules of the program.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The impact of a six-hour professional development workshop on probeware integration was researched. The workshop combined technical probeware instruction with strategies on how to integrate probeware into the classroom and culminated with participants creating personal action plans for using probeware immediately following the workshop. Data was collected from four workshops with a total of 48 participants. The effectiveness of the workshop was assessed by measuring the participants change in comfort level using the probeware and tracking the use of the equipment immediately following the workshop.

The data revealed that the workshop had a positive impact on most participants. The participants' average comfort level using the probeware increased 3.8 points on a 10 point scale, 94% of participants agreed that they were ready to use the probeware in their classroom, and 65% of participants used the probeware within six weeks following the workshop. Probeware integration was most successful in schools with staff who worked together to learn the technology and in schools that had the equipment installed, organized, and easily accessed. The six-hour training had a positive impact, but was not sufficient for complete probeware integration.

INTRODUCTION AND BACKGROUND

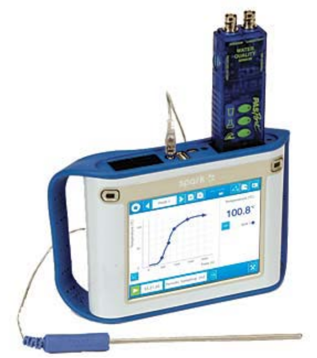

Figure 1. SPARK Science Learning System.

The Education Solutions team facilitates professional development (PD) workshops for PASCO® Scientifics' customers. During these workshops science teachers are trained to use PASCO's SPARK Science Learning System™ (SPARK). The SPARK system allows students to collect and analyze a wide range of data including temperature, pH, force, and pressure. Figure 1 shows a SPARK with two sensors attached. Generically the SPARK system is referred to as probeware, data-collection systems, or data-logging systems.

While PASCO offers a variety of training options, the most common PD workshop delivered is a one-day (six-hour) workshop at the school (or district) that purchased training. The focus of the workshop is to get the participants comfortable with the SPARK system so they can collect and display data in various ways (table, graph, digits, meter). In addition to collecting data the participants learn to use the 60 labs, called SPARKlabs, which are included in the SPARK software. These lab activities contain procedural instructions, pre-made data collection displays, and questions for students to answer. The SPARK system allows the students to record their answers in SPARK's electronic journal and submit their lab in a digital format. During the PD workshops the teachers are guided through these features and allowed time to practice. The workshop participants tend to enjoy the guided technical instruction combined with hands-on practice.

Long term professional development work with the same group of teachers called attention to the fact that a large number of teachers trained never actually used SPARK with their students. During the initial workshops the participants were actively using SPARK to perform lab activities. They were openly enthusiastic about potential uses of SPARK and comfortable with the technology. Furthermore, in the workshop evaluations most teachers “strongly agreed” or “agreed” that they were ready to use SPARK with their classes. Glowing reports of the PD were written in the comments section of the evaluations, such as, “This was the best workshop in my 20 years of teaching!” and “The labs we did will be great for my classes!” It was therefore disappointing to discover that these teachers never used SPARK with their students. Why was this discrepancy occurring? Was there a way to change the PD workshop to help teachers implement SPARK more effectively in their classroom?

Purpose of Research

There were two main goals for this action research project. The first goal was to modify the six-hour SPARK training to emphasize implementing SPARK in the classroom in addition to the technical instruction needed to use the system. The second goal was to determine the impact this newly designed six-hour SPARK training had both immediately after the training and six weeks later. The impact of the workshop would be assessed by determining how the training affected the participant’s comfort level with SPARK and whether or not SPARK was used in the classroom.

Main Research Question

How effective is a six-hour professional development workshop on increasing participant comfort level with SPARK and getting the participants to use SPARK in the classroom?

Secondary Research Questions

1. How did the participants’ comfort levels change after the six-hour professional development workshop and how comfortable were they using the SPARK six weeks later?
2. How often did the participants use SPARK and how did their comfort with SPARK, plans for using SPARK, and the school environment affect SPARK usage?
3. What characteristics do teachers have that help them to integrate SPARK into their classrooms?
4. How will the results of this study impact the design of future professional development workshops?

Significance of Research

Understanding the effectiveness of the SPARK PD workshop delivered is valuable to a variety of people including the professional development staff at PASCO, the district personnel who purchase and organize the trainings, the teachers being trained (and indirectly their students), and other technology-based PD developers. First and foremost, PASCO has an obligation to satisfy the customers who purchase the PD. The school districts expect that the teachers trained will use the equipment with their students. In addition to purchasing the PD, these schools have invested significant amounts of money in PASCO probeware because it is recognized as a valuable tool that can help students engage in scientific processes and learn complex science content. If teachers do not use the technology, the students miss out on these valuable learning experiences and the money invested by the school is lost. Determining the effectiveness of the SPARK workshop will allow PASCO to know whether or not the customers' expectations are being fulfilled.

Once the effectiveness of the SPARK workshop was determined, PASCO's PD workshop developers would use the results to improve the PD delivered and to accurately communicate to customers the behavioral changes they can expect in the teachers who attended the training. While PASCO's PD developers continually strive to deliver the best PD possible, follow-up with school districts, to see how the teachers have implemented the SPARK and whether or not the training met their needs, rarely occurs. This study provides data on how the participants used SPARK in the six weeks following the workshop and on how effective they felt the training was to their implementation of SPARK. This data will be used to modify the PD workshop as needed and to help PASCO's educational consultants explain to potential customers the behavior changes they can expect from their teachers after a six-hour PD workshop. Potential customers will be able to use this information to make informed decisions about purchasing probeware and PD.

Additionally, the results of this action research may help other companies and teachers who design and implement PD workshops involving the integration of technology into the classroom. While technology has become accepted as a valuable addition to schools, teacher PD that focuses on technology has not caused any significant change in the way teachers teach (Valanides & Angeli, 2008). The results of this research may benefit PD designed to help teachers implement a variety of different technologies including simulations, digital images and video, interactive whiteboards, tablets, and online inquiry projects. The results of this study could increase the understanding of effective PD for technology integration and provide teachers and school districts the support they need to improve science teaching and ultimately student learning.

Support Team

I am thankful to many people for guiding me and helping me through the action research process. First, I have learned everything I know about action research from my Montana State Professor Walt Woolbaugh and his teaching assistant Laurie Rugemer. I also received a tremendous amount of support from my classmate Wendy Whitmer. As the Regional Science Coordinator for Northeast Washington, Wendy develops and leads professional development workshops for teachers in her region. Her perspective on professional development has been invaluable. My project reader, Ritchie Boyd, has provided great insight into the challenges of training teachers on the effective use of technology in teaching and the overall clarity of my project. Freda Husic, the manager of the Education Solutions group at PASCO scientific, has brainstormed with me, edited drafts of my paper, and allowed me to discuss and share my ideas with our professional development group at PASCO. Finally, my father, Myron Flindt, listened to all my successes and challenges throughout the process as well as edited several different drafts of my project. I could not have completed this project without the support of all these people.

CONCEPTUAL FRAMEWORK

Science educators approach teaching with their current conceptions of how students learn and how teachers should teach based on what they have acquired from course work, professional development sessions, and professional readings (Collins, 2002). The increasing amount of technology in society as well as the classroom has created the opportunity for new types of learning activities to help students understand science content. The challenge is to help teachers learn about these new teaching activities and fit them into their conception of how the classroom works. Current research on how people learn (children and adults alike) show that learning is enhanced when you start your instruction with what people already know or believe, directly teach some subject matter, and allow people to grapple with and control their own learning (Bransford, Brown, & Cocking, 1999). These latest findings on how people learn were used to design a professional development workshop that would effectively help the participants not only learn how to use SPARK technology, but also integrate it into their instructional approaches.

It is important for teachers to learn technology-based teaching activities because technology use is a requirement in our education system. The use of technology in science education is repeatedly mentioned in the National Science Education Standards (National Research Council, 1996). These standards require that students use technology tools to perform more sophisticated data collection and analysis. Probeware, such as SPARK, is one tool that can be used to meet these standards. Some state standards, such as those in Texas, specifically mention the use of probeware. Probeware is also called out as a valuable tool in privately operated curriculum programs such as the College Board’s

Advanced Placement Biology course and the International Baccalaureate Organization's science courses. The increasing demand for students to use technology as a part of learning and doing science requires that teachers understand the educational value these tools bring to the classroom.

In a review of the literature it is clear that most teachers struggle with implementing technology in their classroom. First, these skills are not being taught in national teacher education programs so teachers have to find their own time to learn these skills (Pederson & Yerrick, 2000). Second, in a review of the literature Higgins and Spitulnik (2008) show that there is a general consensus that using technology effectively is a complex and difficult task. Third, it is not as simple as just learning a new technology. In a study involving 174 teachers surveyed on their use of technology in the classroom, Gorder (2008) concluded that while teachers use technology to deliver instruction and to complete their professional duties, they have a much harder time using technology in ways that enhance student learning. Finally the process of integrating technology takes time. Shane and Wojnowski (2005) worked on a four year technology integration project involving K-8 teachers from two different school systems. Even with continual support on technology integration, the researchers found that it took three to four years for behavioral changes related to technology integration to take place.

The goal of getting workshop participants to learn how to use and implement probeware after six-hours of training would be challenging, so a review of the literature was done to determine characteristics of effective professional development workshops. These characteristics were then used to develop the PD workshop used in this study. Although no articles were found specifically about probeware professional development, there were articles describing effective professional development specifically for technology integration. Flick and Bell (2000) outlined five guidelines that should be followed when preparing science teachers to use technology in their classrooms. These guidelines stated that technology should

- be introduced with science content;
- be used with appropriate pedagogy;
- have the unique features of the technology identified;
- demonstrate how the technology makes scientific views more accessible; and
- show how the technology can be used to develop students' understanding of the relationship between science and technology (p. 40).

PASCO's original six-hour PD workshop fulfilled the first three requirements, but direct instruction on how the SPARK made scientific views more accessible and the relationship between science and technology needed to be added. The missing components were added by starting the PD workshop with a demonstration that measured changes in pressure. Since students cannot "see" pressure, the probeware allowed a phenomenon that cannot be seen to be measured. This demonstration modeled one way technology is integrated in the classroom and also prompted a discussion about *why* probeware should be integrated, which was then continued throughout the workshop.

A case-study conducted by Valanides and Angeli (2008) provided additional information on improving the design of the PD workshop. In this study, 10 science teachers attended seventy 45 minute periods of professional development on how to enhance science learning using computers. The authors concluded that preparing teachers to use computers in an effective way was not an easy task, but they did learn a few things from their experience. First, they strongly recommend that all PD programs include a practical component during which teachers can actually teach using computers. Second, Valanides and Angeli (2008) suggested that teacher educators needed to carefully select the technology tools that they use because, “if the tools [technology] are difficult to learn, then the participating teachers will get caught up in just learning how to use the tools themselves and they will fail to design appropriate computer-supported learning activities” (p. 11).

Both of Valanides and Angeli’s (2008) suggestions were applicable to the PASCO training. After initial instruction and a period of individual exploration, participants in past SPARK workshops were encouraged to present new features they discovered to their colleagues. The teachers who presented gained more confidence and gained experience “teaching” using the SPARK technology. It was therefore decided to incorporate more time for presentations into the PD workshop to ensure each participant was able to present at least once. The second conclusion drawn by Valanides and Angeli, about getting caught up in the technology, was also observed in past SPARK workshops. So much time was spent teaching the SPARK system that the teachers never had the opportunity to think about how they would use it in their classroom. The SPARK software has so many functions that when the teachers succeeded with one, the workshop facilitator would teach the next function, and so on in an attempt to cover as much of the software as possible. The newly designed workshop would present fewer features and spend more time having the teachers plan how they would use the SPARK in the classroom.

Guzey and Roehrig (2009) provided the idea for the biggest change that was made to the newly designed PD workshop. These researchers had the teachers in their PD workshop create a technology integration plan. In this plan the teachers wrote down ways they could use technology in their classroom, when they could use it, and how it could enhance their teaching. In this same plan the participants wrote down constraints they may face in using the technology and how they could overcome some of those obstacles. The authors then compared the teachers' technology plan with what they actually observed in the classroom. This was a strategy that PASCO PD developers had not used before, but would fulfill the need of helping workshop participants with the implementation of SPARK in addition to learning how to use it. The new PD workshop had the participants create their own SPARK action plan outlining three ways they planned to use SPARK immediately following the training.

Technology integration is more likely to occur if the technology-based activities match the participants teaching style and if the activities are customized by the teacher. Higgins and Spitulnik (2008) found that teachers who were asked to implement techniques that were significantly different from their existing pedagogical practices tended to fail. Since PASCO PD workshops train all types of teachers, it was critical that the workshop participants understood that SPARK could be used in a variety of ways to accommodate different teaching styles. To promote technology integration further, the workshop needed to provide the participants with time to customize the activities to meet their teaching needs. In a study with 30 teachers testing middle school probeware curriculum modules, Metcalf and Tinker (2004) concluded that the most important factor for the success of the module was the teacher. The teachers who had customized the activities for their students were significantly more successful than the teachers who used the curriculum exactly as it was provided to them.

The last series of articles referenced were specifically about the ways probeware helps students learn. The students in Yerrick and Johnson's (2009) study reported that using the technology met their needs and learning styles better. The teachers in the study found they could teach topics in less time and that they had a renewed excitement for teaching. Metcalf and Tinker (2004) found that student learning increased for students who manipulated the probes and watched the screen, but decreased for those students who did not touch the probes. Therefore teachers should encourage all the students in a group to take turns manipulating the probes. Finally, Jeanpierre, Oberhauser, & Freeman (2005) have shown that if teachers implement probeware just a few times they will gain confidence and be more likely to use the tool more often and in ways that will improve student learning. The workshop facilitator should share these findings with workshop participants and encourage the teachers to jump in and try the probeware with their students.

The research described above on how people learn, effective professional development strategies for technology integration, and using probeware to increase student learning guided the design of the SPARK professional development workshop. The next section outlines the SPARK workshop, the participants involved in the research, and the data instruments used to assess the effectiveness of the SPARK workshop.

METHODOLOGY

SPARK Workshop Description

The primary goal of this research was to determine how effective a six-hour professional development workshop was on changing the participants' comfort with SPARK and getting the participants to use SPARK in their classrooms. The six-hour PASCO workshop on how to use SPARK differed from a typical PASCO training in two main ways. First, the technical portion of the training, where the participants learn the SPARK, was shortened by removing direct instruction of less commonly used features. Second, the extra time was filled in by training the teachers on the different ways SPARK can be implemented in the classroom and then allowing each teacher time to write down three ways they planned to use SPARK in the weeks following the training, thereby creating their own personalized SPARK action plan. Table 1 outlines the difference between the agenda for a typical SPARK workshop and the modified workshop that emphasized implementation in the classroom. A sample workshop agenda, the SPARK implementation guide, and the SPARK action plan are included in appendix A, B, and C respectively.

Table 1

Changes in PASCO Workshop Agenda

Session (90 min)	**PASCO Workshop – Device with Content (original)**	**PASCO Workshop - Implementation Emphasis (new)**
1	Introductions & SPARK Overview	Introductions, Pre-survey, & SPARK Overview (30 min)
	Periodic Sampling w/SPARKlab	Periodic Sampling w/SPARKlab (30 min)
	Manual Sampling w/SPARKlab	Data Analysis, conclusions, and a discussion on how to implement SPARK in the classroom (30 min)
Break		
2	Show Path- SPARK features	Perform a paper Lab using the Build Path (45 min)
	Build Path w/ paper lab	Presentation of labs (30 min)
	Sensor Exploration	SPARK Action Plan (15 min)
Lunch		
3	SPARKlabs vs. Paper labs	PASCO implementation planning (15 min)
	Saving and File Management	Perform a lab of your choice. (45 min)
	Perform Lab(s)	Presentation of your lab including the sensor you used and SPARK features (30 min)
Break		
4	Perform a lab of your choice.	Practice a challenge activity, demonstration, or group discussion activity (30 min)
	Presentations	Present the activities (20 min)
	PASCO resources	Finalize SPARK action plans (20 min)
	Workshop Evaluation	PASCO resources and Workshop Evaluation (20 min)

The workshop started with a science demonstration of a soda can being crushed and the participants discussed the science behind why the can was crushed. After some hypotheses had been made the demonstration was repeated, this time using probeware, and the data was used to assess the participants' predictions. This introduction allowed the participants to experience some of the advantages of probeware and observe how probeware could be used for demonstrations and class discussion activities instead of only for student labs. After this demonstration the participants were given time to explore using the SPARKs to collect temperature data. The participants were encouraged to discover how the software worked by setting up temperature data in a variety of different displays (graph, table, digit, and meter). The facilitator encouraged the participants to try different features and to share with each other what they discovered. After this initial exploration, the facilitator guided the participants through an overview of the SPARK software.

After the overview the participants were introduced to SPARKlabs (an electronic lab that is pre-loaded on the SPARK unit and has all data displays configured) by having them open up a SPARKlab and work through the first few pages as a group. Once the participants understood the software design, they finished the lab working independently. The participants collected data, answered the lab questions directly into SPARK, and used the electronic journal on SPARK to save their work. After completing the lab the participants reconvened and were shown how to use the SPARK analysis tools to analyze and understand the data further. The analysis was followed by a discussion on how the lab could be changed to meet each individual teacher's goals based on their students' needs and the curriculum they taught. During this discussion the facilitator introduced the teachers to the SPARK implementation guide (Appendix B) that described the various ways SPARK could be used in the classroom. Lastly, the facilitator went over the various ways the saved file could be transferred to the teacher computer for assessment.

After the break the facilitator showed the participants how SPARK was used with paper-based lab handouts. All the instructions for performing the lab were on the handout and SPARK was used to collect and display the data. The participants were encouraged to pick a lab, from the choices provided on the agenda (Appendix A), that they would consider implementing in the next month. The labs available to the participants were chosen prior to the workshop based on the sensors the school had and the standards that the teachers would be teaching in the month following the training. Each teacher (or group of teachers) worked through the lab of their choice at their own pace. The facilitator monitored each group and helped as needed.

After completing the lab each participant (or group of participants) presented the lab they performed. Prior to the presentation, each group practiced transferring electronic files by transferring their data to the facilitator's computer. The presentations included the purpose of the lab, an overview of the lab procedure, the data collected, and how the data was analyzed. These presentations served several purposes. First, the participants practiced saving and managing files between the SPARK and a computer. Second, the participants practiced using the SPARK software in front of a group. Third, the participants learned about the different sensors their school owned, the labs that were done with the each sensor, and how to use various SPARK features.

After the presentations the participants filled out the first portion of their SPARK action plan. At this point in the training the participants had performed two labs, had seen one demonstration, and had discussed the various ways SPARK could be used in classroom. The teachers filled out the rest of their SPARK action plan later in the day after they had time to perform additional activities and discuss implementation ideas with their colleagues.

After lunch the participants performed a lab of their choice. Participants were encouraged to use the implementation guide and their course standards to pick a lab they could use in the first six weeks of the school year. Each lab activity used different features of the SPARK software and thus each group continued to learn the technology as they performed the lab activities. After completing the lab the participants did another round of presentations and each presentation was followed with a discussion of possible ways to customize the activity.

In the last segment of the workshop the participants practiced a short activity that they could do with their students. Teachers who did not have an idea of their own were given a short inquiry challenge. The challenge included a question, but no procedure for the participants to follow. They had to use their understanding of science and the SPARK to answer the questions. Sample challenges are included in Appendix D. After this final challenge, the participants finalized their SPARK action plans. The facilitator ended the workshop by going over the PASCO resources available for them, such as the phone numbers for PASCO’s Teacher Support department and resources available to them on the PASCO website.

Research Design

Sample and Demographics

The SPARK professional development workshop described above was delivered to high school science teachers in four different school districts. The first two trainings were for all of the chemistry teachers in their respective school districts. Both of these school districts had four different high schools and a few chemistry or physical science teachers from each school attended. The third training was for all of the science teachers at one specific high school. There were several biology teachers, two chemistry teachers, and a couple of physical science teachers. The fourth training involved high school teachers who had been accepted into a grant program to improve biology and chemistry teaching. The high school teachers represented 10 different schools in a variety of different school districts. All of the teachers who participated in the workshop taught high school level (grades 9-12) biology or chemistry. There were a total of 48 participants in this study.

There were approximately 10 participants who attended a workshop but were not included in the study. Participants were disqualified from the study if they attended less than half of the six hour workshop, if they were instructional aides or administrators and were therefore not in charge of whether or not the students would use SPARKs, and if they were at a school that did not have SPARKs. Of the 48 teachers who participated in the study 11 were new teachers (taught for three years or less), 29 were experienced teachers (taught for four to 15 years), and eight were very experienced teachers (had taught 16 or more years).

These workshops were selected for the study because they all took place at the beginning of the 2011-2012 school year. Each workshop was held within the first couple of weeks of the school year or in the week prior to school starting. Because it was the beginning of the school year, all the teachers were starting with a new group of students and they would be able to implement the technology fairly early in the school year (as opposed to starting something new mid-year). A description of each workshop is shown in Table 2.

Table 2
SPARK Workshops Used in this Study

SPARK Workshop	**Workshop Description**	**Date**	**Number of Participants**
1 - South Carolina	District A Chemistry	August 10, 2011	11
2 – Texas	District B Chemistry	August 17, 2011	16
3 – Tennessee	Single School All Subjects	August 22, 2011	8
4 - Kentucky	Grant Supported Biology and Chemistry	August 24, 2011	13

The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained.

Data Instruments

To determine the effectiveness of the six-hour SPARK workshop a variety of data sources were collected on the day of the training and up to three months following the workshop. On the day of the workshop three data instruments were collected from each participant. At the beginning of each workshop the participants filled out a pre-training survey (Appendix E). This survey asked the participants about their educational background, teaching experience, and teaching characteristics. At the end of each workshop the participants completed a training evaluation (Appendix F). The evaluation asked the participants about their comfort using SPARK, the likelihood of them using SPARK, and the design of the workshop (length, level of difficulty, content, etc.). As the participants filled out their workshop evaluations the facilitator scanned each participant's SPARK action plan, which had been completed during the workshop, and gave the originals back to the participants. The SPARK action plan outlined three ways each participant planned to use SPARK after the workshop.

The facilitator recorded observations about participants during workshop breaks and as the teachers were presenting to each other. After the workshop ended, the facilitator typed detailed notes about the training and observations about each participant. These facilitator notes were the fourth data source collected on the day of the training.

The workshop facilitator sent participants a post-training survey approximately six weeks after the workshop (Appendix G). The post-survey had the participants report how many times they had used SPARK since the training, how closely they had followed their SPARK action plans, and allowed the participants to reflect on the overall effectiveness of the workshop after having had time to use SPARK in the classroom. The teachers were given approximately three weeks to submit the survey and email reminders were sent out weekly. After the three weeks had passed the facilitator called the participants who had not responded and asked them the survey questions over the phone.

The post-training survey data was used to categorize the participants based on the number of times they used SPARK. The participants who had used SPARK three or more times were classified as frequent users, those who had used the SPARK one to two times were classified as minimal users, and those who had not used the SPARK were classified as non-users. One frequent user, one minimal user, and one non-user were randomly selected from each workshop and interviewed. Getting the participants on the phone was difficult and a second round stratified random sampling was needed to get the desired number of interviews. In the end, six frequent SPARK users, three minimal SPARK users, and five non-SPARK users as well as two science coordinators were interviewed. It took approximately one month to complete all of these interviews. The interview questions used with the teachers and the science coordinators are found in Appendix H and Appendix I respectively.

A variety of data instruments were used to ensure the validity and reliability of the data collected. The data instruments used to answer each research question are summarized in Table 3.

Table 3
Data Triangulation Matrix

Focus Questions	Data Source 1	Data Source 2	Data Source 3
Primary Question:			
How effective is a six-hour professional development workshop on increasing participant comfort with SPARK and getting the participants to use SPARK in the classroom?	Teachers' pre-training surveys, end of workshop evaluations, and post-training surveys	PASCO facilitator observations	Post-training interviews with participants and science coordinators
Secondary Questions:			
1. How do the participants' comfort level change after the six-hour professional development workshop and how comfortable were they using SPARK six weeks later?	Teachers' pre-training surveys and end of workshop evaluations	Teacher post-training surveys	PASCO facilitator observations
2. How often did the participants use SPARK and how did their comfort with SPARK, plans for using SPARK, and the school environment affect SPARK usage?	SPARK action plans	Post-training surveys	Post-training interviews
3. What characteristics do teachers have that help them to integrate SPARK in their classrooms?	Teachers' pre-training surveys	PASCO facilitator observations	Teachers' post training surveys and interviews
4. How will the results of this study impact the design of future professional development workshops?	Teachers' training evaluations	SPARK action plans	Post-training interviews with teachers and science coordinators

In addition to using multiple data instruments to answer each question, a variety of strategies were used to ensure each data instrument gave valid and reliable results. The surveys and interview questions were piloted in workshops prior to this study. Several questions were reworded or replaced based on the data collected. Several PASCO employees as well as a PD developer outside of PASCO read each survey to ensure its clarity. Finally, current PASCO probeware users filled out the pre-survey and post-survey to ensure that the survey questions gave the information required. The SPARK implementation guide and SPARK action plan also went through several revisions. These data instruments were also piloted and significantly changed based on feedback from both the workshop facilitators and participants. The following section reports on the data collected from each data source and how the data was analyzed to determine the impact the PD workshop had on helping the participants integrate SPARK in their classrooms.

DATA AND ANALYSIS

A variety of different data instruments were used to determine the effect the six-hour PD workshop had on participant comfort with the SPARK and the likelihood of using SPARK in the classroom. The first part of this section discusses how participant comfort changed as a result of the training and in the six weeks following the training. The second part describes SPARK usage in the six weeks following the training, how SPARK use compared to the participants' planned use, and the barriers participants faced implementing SPARK. The third section identifies SPARK usage patterns among different groups of teachers including usage by teaching experience, educational background, and classroom practices. The last section reports on insights garnered from the action research approach and how future SPARK PD workshops can be improved.

Comfort with SPARK

Participant surveys, post-training interviews, and facilitator notes were used to determine each participant's comfort level in using SPARK after their participation in a PD workshop. Participant surveys provided data on the average comfort ratings from the pre-training survey, training evaluation, and post-trainings survey. The participants ranked their comfort using SPARK as one if they were not at all comfortable and as a 10 if they were very comfortable using SPARK. The results are shown in Table 4.

Table 4

Change in Mean Comfort with Using SPARK After the Workshop

Comfort with SPARK	**Mean on a 10 point scale (SD)** (N=48)	**Change in Comfort from Before the Workshop**
Pre-Training (morning of the workshop)	3.3 (2.5)	N/A
Training Evaluation (end of the workshop)	7.1 (1.4)	3.8
Post-Training (6 weeks after the workshop)	7.3 (1.5)	4.0

After participating in the six-hour workshop, the average participant increased their comfort level with SPARK nearly four points on a 10 point scale. An independent samples t-test to compare participants' SPARK comfort prior to the workshop and after the workshop indicated a significant difference in the participants' comfort level prior to the training (M=3.3, SD=2.5) compared to their comfort level at end of the workshop (M=7.1, SD=1.4); $t(47) = -9.9$, $p=2.6E-13$. These results suggest that the workshop had a significant effect on increasing the participants' comfort using SPARK. The average participants' comfort level at the end of the workshop was not a perfect 10, suggesting that the participants did not leave the workshop feeling 100 percent comfortable with SPARK. Six weeks after the training, the average participant comfort level had not only been maintained, but also showed a slight, although insignificant increase (0.2 points on a 10-point scale).

In addition to participants reporting an increase in their comfort levels with SPARK, facilitator observations also revealed a general increase in participants' comfort level with SPARK. In the first two hours of each workshop the facilitator was inundated with questions: "How do I…," "What icon did you press?", "Is it possible to…," and "How did you get to that screen?" As the workshop went on the number of questions decreased. By the end of each workshop participants were navigating SPARK software independently, and conversations with participants switched from "how to use" the SPARK to "ideas on ways to use" SPARK to teach different topics. Some participants learned the software quickly while others were shown the same procedures multiple times. Less than halfway through the workshop participants presented their first labs using SPARK. One participant had forgotten to save her work and said, "That's okay, I'll just show you what I did." With confidence she proceeded to teach us how she did the lab, which included several software features that had not been covered yet. This participant had never used the SPARK prior to the training and had gained a tremendous amount of comfort and confidence in only a couple of hours. In the same training, another participant was, "a little hesitant at first, but she worked well and seemed comfortable by the end of the day." Even though participants learned the SPARK system at different rates and to different degrees, they all became more comfortable by the end of the workshop.

On the day of the workshop most of the participants, the science coordinators, and the facilitator reported an increase in comfort levels with SPARK as a result of the workshop. Six weeks after the training the participants continued to attribute their increased comfort with SPARK to the workshop. In post-training interviews participants reported changes in their comfort level with SPARK as a result of the training. One teacher responded, “It was a giant leap!” Another teacher stated, “Oh it changed a lot because I really did not know what I was doing beforehand at all. I am using it a lot more and I feel a lot more confident with it now.” These teachers confirmed that their comfort with SPARK improved as a result of the training. Other teachers stated that their comfort with SPARK increased, but that they still have more to learn and were not completely comfortable. When asked if her comfort using SPARK increased as a result of the training one teacher said, “Absolutely. I would never have opted to use it. I would really like another training though. I don’t feel really comfortable.” While this teacher had come a long way in becoming more comfortable with the device she recognized that she had more to learn and wanted to become even more comfortable. The teachers quoted above explain why the average comfort was approximately 7 out of 10 and not 10 out of 10. Further contributing to a 7 of 10 comfort mean were two participants who already knew how to use the SPARK. When asked how their comfort changed, one of these participants reported, “I don’t think it changed very much because I was already fairly knowledgeable about the SPARKs.” While the average participants showed significantly increased comfort with SPARK, many participants wanted to learn more, and a few felt they did not gain much comfort because they came to the training already comfortable with the SPARK.

The average participant’s increase in comfort level using SPARK was seen at all four of the workshops delivered. Figure 2 shows the average comfort for the participants at each school before the training, immediately after the training (training evaluation), and six weeks after the training.

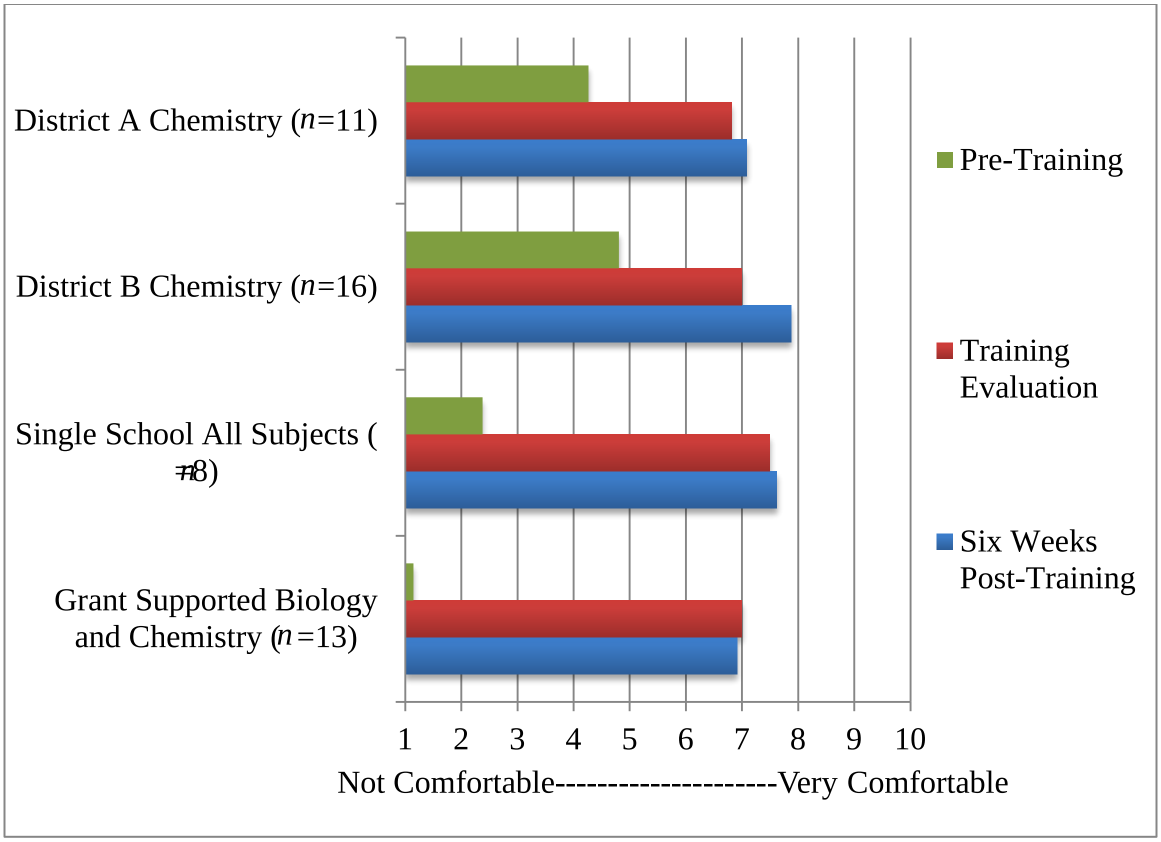

Figure 2. Average Participant Comfort Using SPARK by Workshop, *N*=48.

Most participants left the workshop more comfortable with SPARK than before the workshop, and in general, this comfort was maintained for the next six weeks. Another similarity among the workshop averages is that at the end of the training and about six weeks after the training, most participants reported a comfort of approximately 7 out of 10 with using the SPARK. A difference among the four workshops was the average pre-training comfort level. Participants in the District A Chemistry and District B Chemistry workshops reported a higher initial comfort with SPARK than the participants in the other two workshops. Also, participants in the Single School workshop reported a higher initial average than those at the Grant Supported workshop. Additional one-tailed independent samples t-tests were conducted for each individual workshop to determine if the increase in comfort was significant. The results of these tests suggested a significant effect on participants' comfort with SPARK (District A Chemistry; $t(10) = -3.4$, $p=0.0036$; District B Chemistry; $t(16) = -37$, $p=0.0012$; Single School All Subject; $t(7) = -8.4$, $p=3.3E-5$; Grant Supported Biology and Chemistry; $t(12) = -13.3$, $p=7.66E-9$).

The observed difference in the initial comfort level is likely due to the length of time the participants had access to the SPARKs. Participants in both of the district level chemistry workshops had owned the SPARKs for just over a year. Both of these school districts received their SPARKs in the summer of 2010 and also had training in the summer of 2010. Many of the teachers had access to the equipment for an entire year. The participants at the Single School workshop received their SPARKs in May of 2011. These teachers had them at the end of last year and over the summer. A few of these teachers explored the SPARKs prior to the PASCO training. On the other hand, the teachers who attended the Grant Supported workshop received their SPARKs on the day of the training. The longer the schools owned the SPARKs the greater the initial level of SPARK comfort was for the participants.

While the average comfort of the participants was higher for those schools that had owned the SPARKS the longest, these schools also had the greatest variation in skill level of the users as seen by the standard deviations reported in Table 5.

Table 5

Comfort Using SPARK by Workshop on a Scale of 1 to 10

Workshop	**Sample size (*n*)**	**Mean Pre-Training Comfort with SPARK (SD)**	**Mean Training Evaluation Comfort with SPARK (SD)**	**Mean Post-Training six weeks after the workshop (SD)**
District A Chemistry	11	4.3 (2.7)	6.8 (1.3)	7.1 (1.1)
District B Chemistry	16	4.8 (2.4)	7.1 (1.8)	7.6 (1.6)
Single School All Subject	8	2.4 (1.8)	7.5 (0.5)	7.6 (1.6)
Grant Supported Biology and Chemistry Teachers	13	1.2 (0.4)	7.1 (1.4)	6.8 (1.6)
Total	48	3.3 (2.5)	7.1 (1.4)	7.3 (1.5)

The district-wide trainings had the highest initial averages and the highest variation among users in their pre-training comfort level with SPARK. This suggests that some of the teachers had used the SPARK more than other teachers and had become more comfortable with the technology. For example, in the District B training one participant used the SPARK monthly in the previous school year and facilitated a SPARK training for chemistry teachers in the district. This teacher was passionate about using the SPARK and rated her comfort as a 10/10 on her pre-training, workshop evaluation, and post-training surveys. Three other teachers in the same district reported their comfort level as 2 out of 10 on the pre-training survey and said they had not used SPARK in the previous school year. It is clear that these two use case scenarios produced teachers with differing comfort levels.

The chemistry teacher who hosted the District A Chemistry workshop described a similar scenario. She had used the SPARK six times in the previous year and rated her pre-training comfort as 6 out of 10. During the set-up for the workshop she expressed concern that her colleagues had not used the SPARKs the previous year. Additionally, the biology teacher who ordered PASCO equipment for the Single School All Subject training was eager to use the equipment for her aquatic research class. She explored the use of probes with SPARK before the initial training and therefore reported a slightly higher comfort with SPARK than her colleagues who had not tried out the equipment. The teachers who had used the SPARKs prior to the training reported a higher initial comfort level with SPARK.

Participants were sorted into three groups: advanced SPARK users (a pre-training comfort level of seven or higher), intermediate SPARK users (a pre-training comfort of three through six), and beginning SPARK users (a pre-training comfort level of a one or a two). Figure 3 illustrates the pre-training, training evaluation, and six week post-training comfort levels of advanced SPARK users, intermediate SPARK users, and beginning SPARK users.

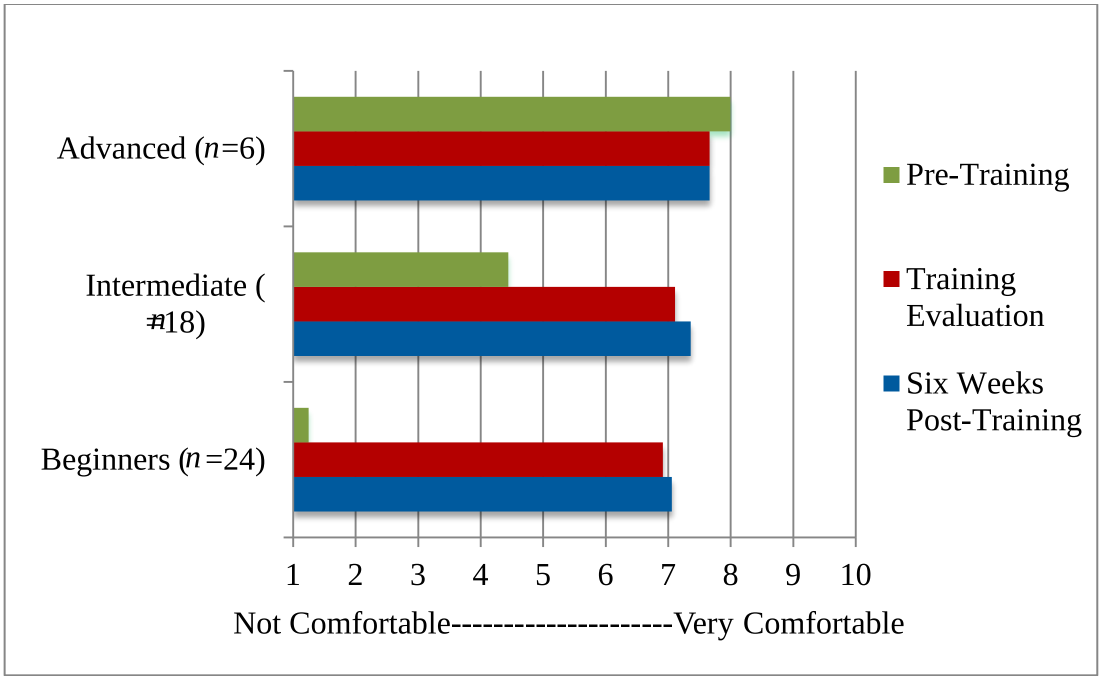

Figure 3. Change in Comfort with SPARK Based on Initial SPARK Comfort, *N*=48.

The data shows that the workshop was the most effective in increasing comfort with SPARK for beginners, somewhat effective for intermediate SPARK users, and not very effective for advanced SPARK users. At the end of the six-hour training, participants categorized as beginners showed a 5.6 point (of 10) increase in their comfort level, while intermediate users increased 2.7 points, and advanced users actually decreased their comfort with SPARK 0.3 points.

The comfort levels are self-reported values and a few participants offered interesting observations. One participant stated that her initial comfort with SPARK was a six and in the comments box wrote that she had never used SPARK, but she generally was good at technology. Another participant identified her initial comfort with SPARK as a seven and at the end of the training she identified her comfort as a three. From observations in the workshop she was ranked as a four because she seemed to struggle with using the SPARK. In the interview she described her comfort with using SPARK as "very comfortable" and she thought "they [were] very user friendly." In her next statement she explained, "Since I am not able to use them very often, it is something new to learn every time." She thinks the SPARK is user friendly which may explain her comfort as fairly high. However, when she actually uses the device and gets stuck, her comfort level decreases. Six weeks after the training she said her comfort level was at a six. Despite a few exceptions the data shows that most participants (88%) improved their comfort with SPARK after the training. Two participants stayed the same (4%) and four participants reported a decrease in their comfort level (8%). Table 6 summarizes these values.

Table 6
Individual Changes in Comfort with SPARK

Comfort Level	**Number (*N*=48)**	**Percent**	**Changes Explained**
Increased	42	88	Increased 2 to 7 points
Stayed the same	2	4	1 participant stayed at 6 1 participant stayed at 10
Decreased	4	8	4 participants dropped levels: 6 to 5; 7 to 3; 7 to 6; and 10 to 8

Both the average data and the individual participant scores indicate that most participants increased their comfort with SPARK. The increase in comfort level was most substantial for participants who were very new to the SPARK. Those who benefited the least from the training were participants who were already advanced users. The data indicates that the workshop was successful in increasing the participants' comfort with SPARK. However, being comfortable with a new technology does not mean participants will actually use the technology. The next section analyzes participants' implementation of SPARK in the classroom, their actual use of the device compared to their expectations of using SPARK, how their comfort with SPARK influenced using SPARK, and the barriers participants reported when implementing the device in their classes.

SPARK Use After the Workshop

In addition to developing comfort in using SPARK software, the PD workshop was also designed to facilitate the use of SPARK in the participants' classrooms. To do this, SPARK use in the form of demonstrations, class discussions, and lab activities was modeled, discussed, and practiced. Each person left the workshop with a personalized SPARK action plan (Appendix C) which outlined three activities they planned to use with their students on their return to the classroom. Six weeks later participants were surveyed to ascertain their SPARK usage, the amount of their SPARK action plans completed, and any barriers they faced implementing SPARK.

In the six weeks following the workshops, 31 participants (65%) used SPARK and 17 participants (35%) did not. Although nearly two-thirds of the participants used SPARK, the amount of use varied. Figure 4 illustrates the percent of workshop participants who used the SPARK frequently (three times or more), minimally (once or twice), the total who used SPARK (frequent + minimal), and non-users.

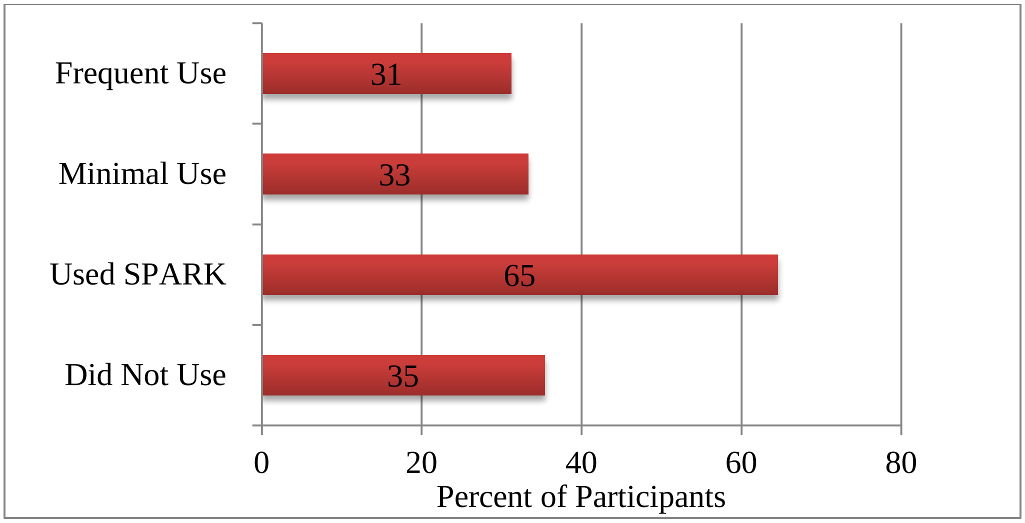

Figure 4. Percent of Workshop Participants Who Used SPARK, (*N*=48).

Approximately a third of the participants used SPARK frequently, a third tried it once or twice, and another third did not use it at all. Why did some participants use SPARK while other participants did not? Several variables may contribute to the use of SPARK. Characteristics such as teaching experience, education background, and level of courses taught are discussed in the next section, *Teacher Characteristics and SPARK Use*. This section focuses on the effect of the participants' comfort level with SPARK, how they planned to use SPARK, and the teaching environment on SPARK implementation in the classroom. The mean participant comfort level with SPARK for those who used SPARK and those who did not is shown in Table 7. Participant comfort level was self-reported with Likert style questions and should not be confused with SPARK competence, which was not measured.

Table 7
Use of SPARK and Comfort with SPARK

SPARK Use (*n*=)	**End of Workshop Mean Comfort Level with SPARK (SD)**	**Six Week's Post Training Mean Comfort Level with SPARK (SD)**
Did Not Use (17)	6.7 (1.7)	6.3 (1.3)
Used (31)	7.3 (1.3)	7.8 (1.4)

At the end of the workshop, the mean comfort level of participants who did not use SPARK was lower than the participants who used SPARK. This difference was not statistically significant ($t(47) = 1.4$, $p=0.09$) and consequently, comfort in using SPARK cannot explain why some participants used SPARK and others did not. Six weeks later though, the mean comfort level of non-users decreased 0.4 points while the mean comfort level of SPARK users increased 0.5 points. These changes resulted in a statistically significant ($t(47)=3.6$, $p=0.0004$) difference in the mean comfort level between participants who used SPARK and those who did not. Long term comfort with SPARK is enhanced when participants use SPARK and diminishes when participants do not use SPARK. Furthermore, feeling comfortable with SPARK does not guarantee that the participant will use it with their students.

Did these participants leave the workshop expecting to use the equipment with their students? Participants responded to two statements in the workshop evaluation that shed light on their expectation to use the equipment: "I am ready to use SPARK in my classroom" and "I will follow my SPARK action plan." Responses were in the form of strongly agreed (SA), agreed (A), were neutral (N), disagreed (D), or strongly disagreed (SD). Figure 5 shows the percent of workshop participants who selected each category.

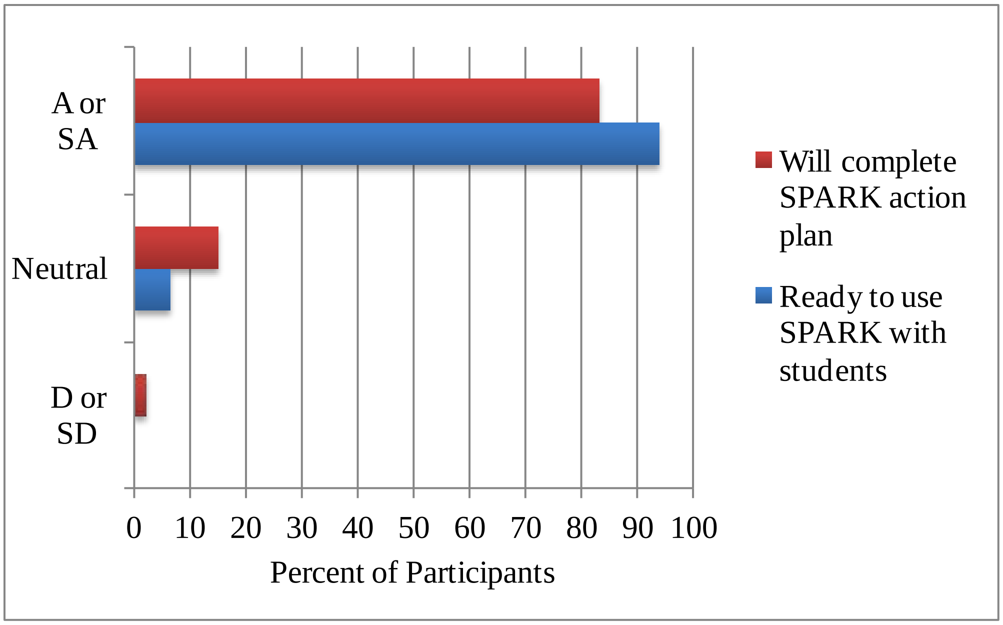

Figure 5. Readiness to Use SPARK and Complete Action Plans, (*N*=47).

Over 90% of the workshops participants agreed or strongly agreed they were ready to use SPARK with their students, but only 65% of participants used the device. Approximately 25% of the workshop participants who acknowledged being ready to use SPARK, never actually used it. More tellingly, over 80% of the participants agreed or strongly agreed they would complete their action plan and less than 5% completed it. Figure 6 shows the percentage of participants who completed varying degrees of their self-created action plan.

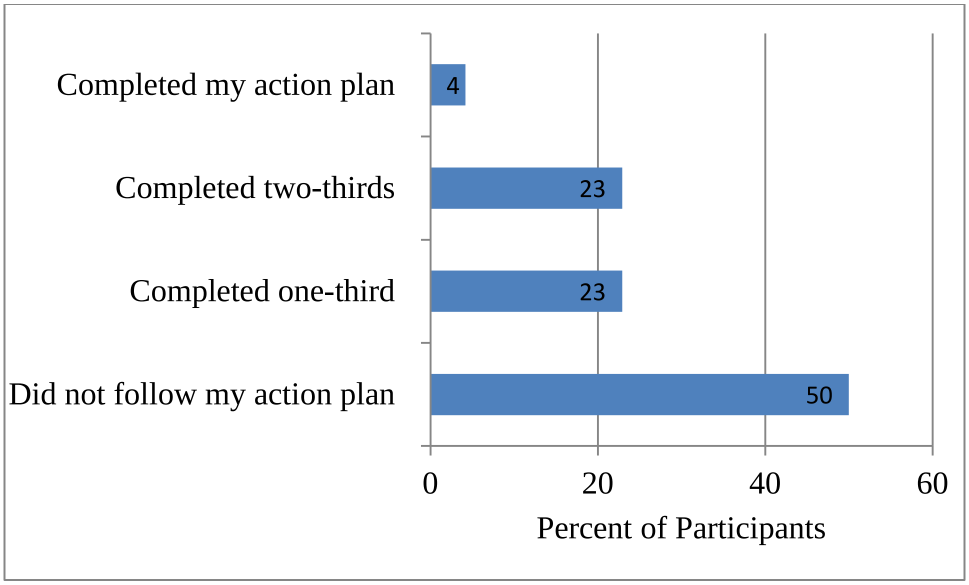

Figure 6. Amount of SPARK Action Plan Completed, (*N*=48).

Half of the participants did not follow their action plan at all. Four participants (8%) agreed they were ready to use SPARK, but were neutral on whether or not they would follow their action plan and one participant (2%) stated she would not follow her action plan and she did not.

Why did the teachers' plans for using SPARK deviate from their actual usage? What causes a workshop participant who is comfortable using the technology, acknowledges they are ready to use it with their students, and says they will complete three self-chosen activities not to use the equipment? The data suggests that workshop participants need to feel comfortable using the device and commit to their selected activities in order to use SPARK in the classroom more. To understand the additional factors contributing to SPARK implementation, the data was analyzed at the workshop level and at individual participant behaviors in their unique school environments. Table 8 summarizes the frequency of SPARK use by participants at each workshop.

Table 8
Use of SPARK Six Weeks after the Training by Workshop

Workshop	**Sample size (*n*)**	**Used (%)**	**Frequent (%)**	**Minimal (%)**	**None (%)**
District A Chemistry	11	7 (64)	5 (45)	2 (18)	4 (36)
District B Chemistry	16	11 (69)	3 (19)	8 (50)	5 (31)
Single School All Subject	8	6 (75)	4 (50)	2 (25)	2 (25)
Grant Supported Biology and Chemistry Teachers	13	7 (54)	3 (23)	4 (31)	6 (46)
Total	48	31 (65)	15 (31)	16 (33)	17 (35)

Single School All Subject

Each workshop had approximately two-thirds of the participants use the SPARK at least once. The Single School All Subject workshop had the largest percentage of total users (75%) and the largest percentage of frequent users (50%). This workshop also had the lowest number of non-users (25%). Explanations for these participants having the highest percent usage of SPARK include: the teachers had a positive and supportive relationship with each other; the SPARK equipment was installed and easily accessed through their check-out system; and the teachers grasped the processes of integrating SPARK into their current curriculum along with instructional strategies, and practiced these specific activities during the workshop.

Mutual support among the teachers was evident on the day of the workshop because participants exuded a positive determination to learn as much as possible both individually and together. When they first turned on the SPARKs the participants erupted with comments such as “This is cool,” and “Awesome!” These comments were immediately followed with questions such as “Can we change the units?” and “Can we graph it?” This initial enthusiasm, common in most workshops, was unusual in that it lasted all day. Two participants finished the first lab activity, before the rest of the group, and proceeded to redo the experiment changing one of the variables. Later in the afternoon when participants were forming implementation plans, a chemistry teacher suggested to her colleague, “Let’s each do one of the chemistry SPARKlabs so that we can see all of them. I will do Percent Oxygen if you do Intermolecular Forces.” These teachers performed the labs individually in order to get exposure to a larger number of activities and to get hands-on experience. Teachers in the other workshops tended to work in small groups with one participant conducting the lab while the others watched. In addition to working independently, each teacher in the Single School All Subject workshop also presented at least one lab to the rest of the group while others watched and asked both content and technology-based questions. In the other workshops one person from the group presented and there were very few questions.

The support among the teachers was also evident in the post-training interviews. The four teachers who were interviewed referred to one or more other teachers at some time during the interview, pointing to a collaborative and supportive environment. For example, one of the teachers who had not used the equipment explained that “pressure and gas laws are coming up and [my colleague] and I were talking of doing a lab with SPARK.” She further explained that next semester she and her colleague planned to do the same activities, but would stagger their schedule in order to share the equipment. The teachers talked about each other in positive and helping ways, which was less common in the interviews with teachers from other workshops. Teachers from this school had an exceptionally strong and supportive department.

Another factor promoting high usage of SPARK in this school was that their equipment was organized and ready to use prior to the workshop. SPARK software was installed on all the computers, the equipment was inventoried, and a computer-based equipment sign-out procedure was in place. In a post-training interview, a participant who had used the equipment explained how easy it was for her to access the equipment.

> We have a shared folder and we have a shared calendar and we can type in what days we want to use it. We have a list of equipment and a calendar. Like I was just thinking I want to use them tomorrow for a demo so I looked it up and it was available so I could sign up.

Even teachers who had not used the equipment commented on the ease of the equipment checkout process. “Yes it is [easy]. We have a sign-up sheet and if it is not signed up you just sign up.” All teachers knew and understood how to get the equipment and had all the software in place to start using it immediately.

Also contributing to the use of SPARK was the teachers’ knowledge and deep understanding of the science subjects they taught. The teachers in this training demonstrated strong content knowledge by quickly and easily explaining the science involved in the activities they completed and immediately recognizing how the SPARK helped them teach the content. In other workshops, teachers with less content knowledge spent their time trying to understand the science involved in the activity and therefore had less time to think about integrating the technology into their classroom. The Single

School All Subject teachers' solid understanding of their course curriculum along with their facility in incorporating SPARK into their lessons meant that more of these teachers would complete all or some of their action plans. Six of eight participants (75%) completed two-thirds of their plans in the six weeks following the training. Only half of the 48 participants carried out some portion of their plans. The degree to which participants completed their action plans is described in Figure 7. This data was self-reported by the teachers in the post-training survey.

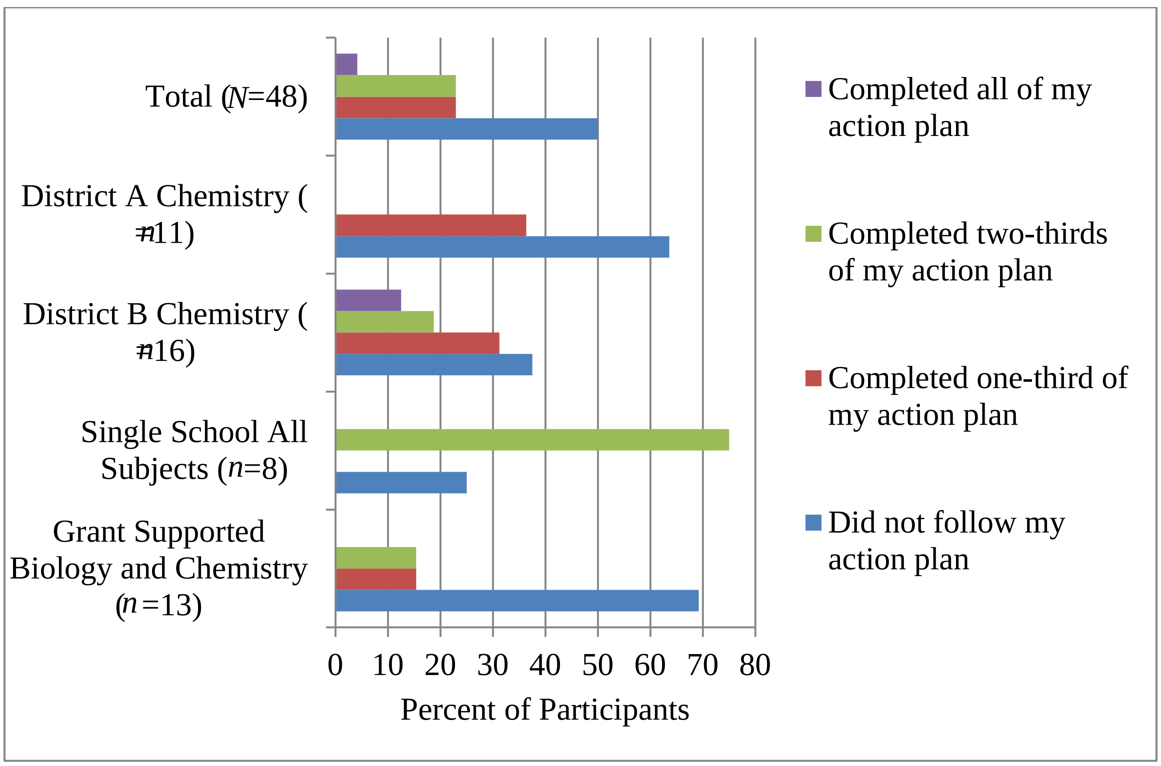

Figure 7. Amount of SPARK Action Plan Completed by Workshop, (*N*=48).

The fact that this school completed significantly more of their action plans may be due to the amount of course content they covered and the degree of seriousness with which they treated their SPARK action plans. Students attend daily 68 minute classes and complete a full year of science in one semester. Therefore in a six week period the teachers had their students for more time and could cover more material than teachers whose curriculum was spread out over an entire year. Besides having more time with their students, these teachers took the SPARK action plan more seriously than participants in other workshops. Teachers discussed the labs they would implement before picking a lab. In other workshops the labs were picked with little, if any, discussion. Furthermore, even though a participant did a lab in the workshop, it did not mean that they included it on their action plan. For example, one teacher noted that one of the sensors they had purchased - the three-axis accelerometer - was difficult for her to learn and that the lab was confusing. She found a different lab that taught acceleration using a motion sensor instead. In her action plan, this teacher selected a lab she thought was best for her students and did not choose the one she performed in the workshop. Her selection of an appropriate lab illustrated that she considered what students need to learn and how they learn, and then integrated the use of the technology to enhance learning further. Several teachers in this workshop exhibited this trait of evaluating the situation and applying a fitting solution. Among others mentioned above, this factor contributed to the higher-than-average use of SPARKs for teachers in this workshop.

Even with this supportive environment 25% (two out of eight) of the teachers at the Single School All Subject workshop did not use SPARK in their classes. Teachers had a variety of reasons for not using the technology. One teacher described how much material she had to cover in her biology class and added, “I have not really had time, plus I don’t know how well they will do. I am afraid they will have more questions about it that I can’t answer.” This teacher was concerned about not knowing enough to help her students. Yet, at the end of the training she evaluated herself as 8 out of 10 (well above the average) in comfort level with the technology. Her high self-evaluation of comfort did not give her the confidence she needed to use the equipment. Six weeks later she dropped her comfort level to 5 out of 10. The other teacher was preoccupied with becoming certified to teach physics by the following semester and could not focus on thinking about using SPARK in her classroom. Her comment about taking the Praxis attests to her distraction. “It is nothing with you or the equipment. It is just, that was literally the point where the principal looked at us and said I am willing to pay for one of you to take the Praxis and I was the one who agreed.” She expressed that the technology was easy and it would not be a problem for her to pick it up again. Her reported comfort scores at the end of the training and six weeks later were both 8 out of 10. Despite these barriers both teachers were optimistic about using the SPARKs the following semester.

Other variables differentiated the Single School All Subject workshop from the other workshops. First, this was the only workshop designed for all the science teachers in a single school. The teachers knew each other and were already working well together. Second, this workshop was organized by one of the teachers who also participated in the training while the other workshops were organized by curriculum directors or grant coordinators. And finally, this training took place two weeks after the school year started (as was the case for the Grant Supported Biology and Chemistry workshop). Preparation for the beginning of the school year was over and the teachers had settled into their new classes and routines were beginning to form. Further research is necessary to determine the effects these variables may have on implementing technology into the classroom.

District A Chemistry

From the beginning, several conditions contributed to a less successful learning experience for the District A Chemistry workshop participants. The workshop started late because the SPARK software was not installed, the SPARK units had not been maintained, and some of the sensors were missing. Trainers updated the equipment at the school hosting the workshop, but that meant the other schools in the district would need to do this on their own. The one-day training was held the week prior to school starting and was the third full day of professional development for these teachers. Many were anxious to get their classrooms set up and prepare their materials for the first week of school. Another distraction was teachers who were called out for other meetings or late returning from lunch. Lastly, since the school district owned the SPARKs the previous year some teachers were already using the technology regularly in their classrooms. This resulted in a split in the attendees with some teachers at the beginner level and others at an intermediate level.

Despite these challenges, six weeks after the workshop 64% (seven out of 11) of the teachers had used the SPARK and 45% of the teachers (five out of 11) used them frequently. Of the seven participants who used SPARK, three had used SPARKs with their students the previous year. Two of the teachers who had not used SPARK in the previous year were new to the school district and brand new to SPARK. The other two teachers had been in the previous training a year ago but had not used the SPARK until after the second workshop. On the post-survey, when asked about the effectiveness of the training one of these teachers responded, “I was not using it before and now I am,” implying the workshop prompted her to integrate SPARK into her classroom. The remaining four teachers did not use SPARK after the training and this was the second round of training for three of these teachers.

The non-SPARK users identified two barriers for not using the technology. Teachers cited poor access to equipment as one barrier. “There are two sets of sparks to share and they are kept upstairs so it is difficult to access.” Another explained that she did not use the SPARKs yet because “I'm waiting for my time.” In the interview this teacher stated she had done a total of three labs in nine weeks. A teacher that does not do very many labs has few opportunities to use lab-based equipment. This same teacher went on to explain that, “there are seven of us that actually want to use the SPARK, but then Mr. X, he is the guy that has them all the time.” These teachers believe that they lack access to the equipment.

Teachers’ inability to integrate the technology effectively into the curriculum was the second barrier. One teacher explained, “We are not at a place in the curriculum where it is appropriate to use SPARKS.” There are at least two or three opportunities in a six-week period of chemistry curriculum for teachers to implement a probeware-based activity with their students. This teacher appeared to be avoiding use of the technology with the students. Another teacher, who frequently used the SPARK and was new to the district, found it difficult to integrate SPARK into the curriculum. She explained that the curriculum was very different than in her previous school. Lack of opportunity for inquiry seemed to be the reason. “This curriculum is more bam, bam, bam. It is more memorizing of concepts. Memorize Hund’s rule, memorize the Pauli exclusion principle. I have not taught it like this. I have taught trends of the periodic table, but I do not have students specifically memorize each one. I teach the big idea.” The first six weeks of the schools' curriculum may not be conducive to probeware. On the other hand, the teachers may not know how to integrate the probeware due to a lack of content knowledge. Teachers indicated they were "scared to death" to teach chemistry, and most did not have a degree in chemistry. Not understanding the chemistry content well enough to know where or how to integrate the SPARK is a contributing factor to non-integration of technology.

District B Chemistry

The District B Chemistry workshop was similar to the District A Chemistry workshop, but smoother. The District B Chemistry was held the week before the first day of school; it was the teachers' third full day of professional development, and the schools owned the SPARKs the previous year so the participants' initial skill level varied. The management of the equipment was slightly better at this workshop: teachers were grouped by their schools and each school brought their own probeware; the school hosting the workshop had additional probeware for those who did not bring the correct equipment; each school had the opportunity to learn how to install and update the equipment; teachers were at the training all day and had a more supportive environment.

The District B Chemistry workshop had a similar percent of participants use SPARKs as the District A Chemistry workshop (69% compared to 64% respectively). The amount the SPARKs were used, however, was quite different. In the District A Chemistry workshop 45% of participants used the SPARK frequently, while in the District B Chemistry workshop only 19% of the participants used the SPARKs frequently. This difference may be due to the length of the class periods. The block schedule in District A consisted of 90-minute periods every other day. The traditional schedule in District B consisted of 50-minute periods every day. When students (and teachers) are new to the equipment, probeware-based labs can take longer to complete as users learn the technology. One teacher explained, “I have been working with my mentor and she has been working with me to modify the labs. The labs are great; I almost wish we had block scheduling because it is just so hard to get to everything in 50 minute periods.” Not only is it hard to complete some of the labs, but the logistics of collecting equipment and sharing SPARKs becomes more difficult. Another teacher expressed her issue, “I adapt the labs because sometimes I have limitations of time, and space, but I still think that the technology is really good.” The fact that the teachers have to “adapt” the labs before they can be used requires more time and effort than using pre-made material. This may explain why the teachers in the District A Chemistry workshop used the equipment less often than other teachers.

Other than the shortened class period, the successes and challenges discussed in the previous workshops were similar in the District A Chemistry Workshop. Teachers who had used the equipment the first year continue to use the equipment and were increasing the number of activities that used SPARK. Teachers, who had not used the SPARK in the previous year, implemented it for the first time this year and were getting help from their colleagues. A teacher who uses SPARK frequently and manages the SPARK check-out system at her school compared usage between the first and second years: “Much, much larger. Each year there are more and more people. When we started, there were only three of us that used it. Others were not too sure. The more people see us using them, the more interested they are to use them. If the kids are doing it just fine, they start to inquire about using the equipment.” While other schools in the district are not as organized and struggle to share equipment, this school has the equipment very organized and teachers are willing to help each other.

In addition to struggling with sharing the equipment, teachers from the District B workshop also face many of the same barriers as teachers in other workshops. Several teachers reported frustration with being forced to follow a "strict curriculum" that does not lend itself to labs. Class periods are short, the curriculum is long and therefore, "I need more time for additional activities." These teachers are struggling to integrate the probeware into a demarcated curriculum with little opportunity for insertion of lab activities.

A first year teacher was afraid of not knowing the answer in front of her students. "But telling 30 students how to use it, if they ask me a question I can't answer—I am supposed to be the content expert and for them to ask me a question that I can't answer—that is where I draw the line." On the other hand, other teachers accept what they do not know and encourage their students to teach them. "The kids they love them [SPARK]. I think they are very user friendly and some of the stuff I don't know how to do, they [the students] do." These two different beliefs affect whether or not the equipment is used.

Grant Supported Biology and Chemistry

The Grant Supported Biology and Chemistry workshop was different than the other workshops. Each participant received one SPARK unit and one set of sensors and the teachers involved in the grant came from a wide number of schools (and school districts) throughout the region. Teachers received their SPARKs and sensor bundles on the day of the training. The equipment was updated and they had all the equipment they needed. This was the first time the teachers had touched SPARK and thus, all were at the same level. The workshop had an incredible positive energy because the teachers were so excited to be given so many resources.

Despite the positive energy at the workshop, this workshop had the lowest number of participants, 54% (seven out of 13), using their SPARKs after the training. Of the seven participants who used the SPARKs, three used them frequently while four only tried them once. One of the frequent users actually used the SPARK 10 times in six weeks! At the workshop, this participant mentioned several times how excited he was to finally be able to use this equipment. He was paging through the lab manual picking out all the activities he wanted to try. Although he only had one unit, for him it was enough to dive in and get started. Another frequent SPARK user explained his use. “The only thing I have done is demonstrations, but it has been great. Kids love it. The only reason I have not done more is because we are supposed to get six to eight more and for some reason we have not got those in yet.” It was clear this teacher would use the equipment more when he had a class set.

Two reasons contribute to lower-than-average usage. The most important reason is that the participants only had one SPARK. While this eliminates the complication of sharing equipment, it also eliminates the possibility of having students use the equipment to perform lab activities in small groups. With one set of probeware, the teacher can perform classroom demonstrations and set up station-based labs in which one station uses the SPARK. Although the teachers were excited to have the equipment and to learn what could be done with it, six weeks later they were not excited. “It is impossible to have students use it when I only have one SPARK!!! Even working in stations, I need three

SPARKs and three sets of probes to be used. My school doesn't have the budget for them!!" Other teachers expressed similar concerns. "I do not have enough SPARKs to be beneficial for student use." And, "I'd like to have more of them. I know we won't be able to have a classroom set but maybe three to four students sharing one would be really nice to have." Teachers also expressed concern in having only one SPARK unit that students could break or misuse, leaving them with no functioning unit.

Teachers also struggled to use the equipment because no one else in the school could help them on a daily basis or discuss ways to use the equipment. After using the equipment for six weeks, several teachers reported that support in using the SPARK had come from colleagues. One teacher, from the District B Chemistry workshop, expressed, "My colleagues are also very supportive. I think they are pretty knowledgeable about the SPARK." The teachers in the grant program do meet regularly and talk with one another, but they do not have the day-to-day support that the teachers in the other workshops had. They lack colleague support in remembering how to use the device and in generating ideas on integrating it into their curriculum. In addition to the barriers unique to this set of teachers, the teachers in the Grant Supported Biology and Chemistry workshop also reported the barriers described by participants in the other workshops.

Summary of Barriers to Using SPARK

While all the workshops had two-thirds of their participants use SPARK only a third of these participants were using the device frequently. Figure 8 summarizes the main barriers teacher from all the workshops reported that make it difficult to use SPARK in their classrooms.

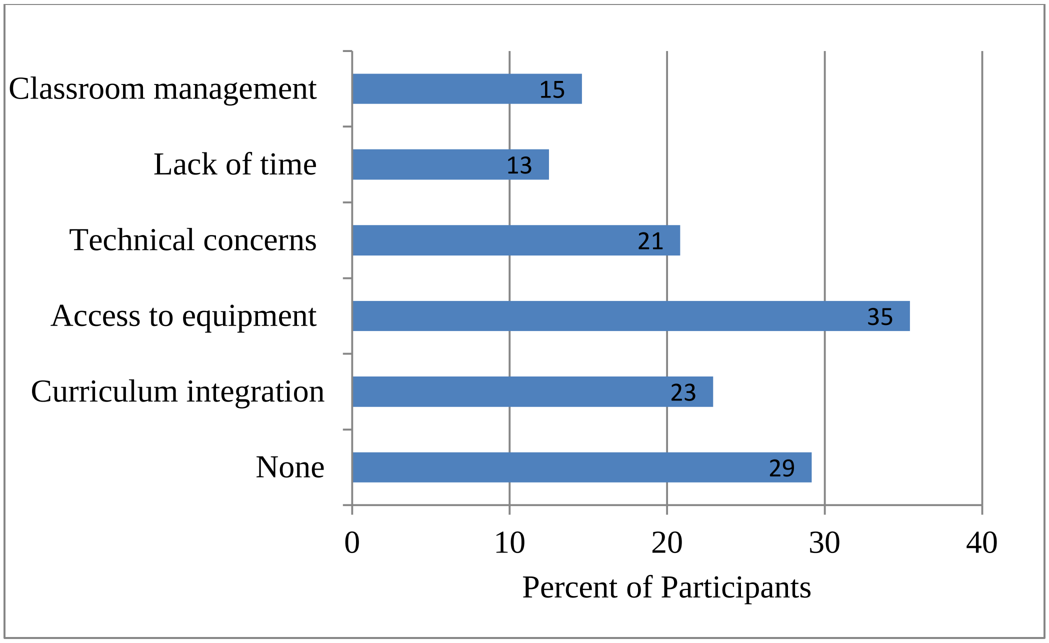

Figure 8. Barriers that Prevent the Use of SPARK in the Classroom, (*N*=48).

The largest number of participants, 35%, reported access to the equipment as one of the main barriers to using the SPARK. This category includes problems associated with sharing equipment, not having enough equipment, not having enough money to buy consumables for the activities, and not having equipment that matches the course curriculum. The next largest barrier, reported by 25% of participants, was curriculum integration which includes needing help on knowing what labs to use and when to teach them. Technical concerns were noted by 21% of the workshop participants. This included SPARK units not working, worrying about not knowing how to troubleshoot problems, and an overall lack of confidence using the equipment. Issues related to classroom management were reported as a concern by 15% of the participants. These concerns related to students misusing or breaking the equipment, what to do with difficult students, and dealing with a large number of students on a daily basis. Only 29% of participants did not have any barriers to using SPARK.

The SPARK workshop effectively facilitated the use of SPARK by 65% of the participants. Several participants who planned to use SPARK, however, did not. While there was little difference in the comfort level of participants who used SPARK and those who did not, there were many other variables contributing to SPARK use. Factors associated to the school environment including the supportive nature of the science staff, the alignment of the curriculum and the equipment owned, and class length affected SPARK usage. In the next section, characteristics of individual teachers will be explored to determine if probeware integration was easier for certain categories of participants.

Teacher Characteristics and SPARK Use

Did the workshop participants who used SPARK share any common characteristics that made probeware implementation easier for them? Could these characteristics explain why some workshop participants used SPARK and others did not, even when they reported similar comfort levels with SPARK. Furthermore, could the PD workshop design be improved by accounting for these characteristics? The characteristics researched included teaching experience, educational background, the level of science courses taught, the use of other forms of technology in the classroom and the number of labs the teacher had their students perform. Prior to the start of the training, each participant answered questions about these characteristics on the pre-training survey (Appendix E). Additional information about these characteristics was gained from the post-training interviews (Appendix H lists the interview questions).

Teaching Experience

The first teacher characteristic examined was years of teaching experience. Of the 48 participants, 11 had taught three years or less, 29 had taught between four and 15 years, and eight teachers had taught for over 15 years. Figure 9 shows the percentage of teachers in each of these categories that used SPARK in the six weeks following the training.

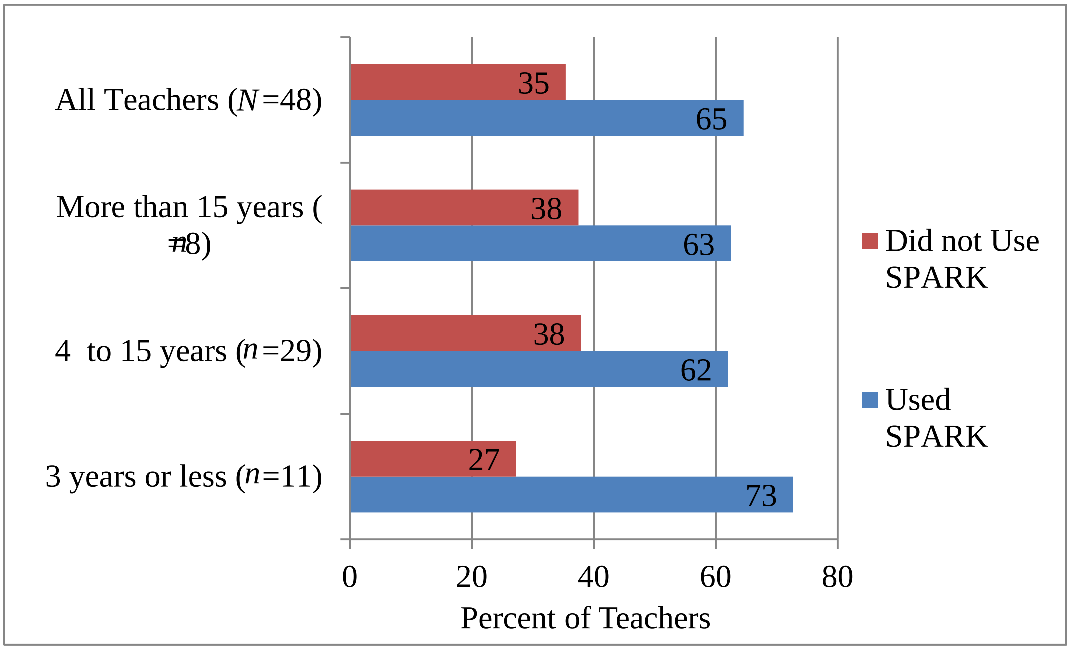

Figure 9. Teaching Experience and SPARK Use.

Out of the 11 new teachers surveyed 73% (8/11) used SPARK. This was a higher percentage of SPARK use than either the teachers with four to 15 years of teaching experience (62%) or very experienced teachers (65%). New teachers may have a slightly higher percentage of use because they are still developing a teaching style and may be more open to new ideas. Less experienced teachers may also be looking for activities to use, while more established teachers already have activities that work well. When asked to describe the characteristics of teachers using SPARK, a frequent probeware user explained, “I would say new teachers tend to use it more. Teachers that have been around longer don’t use it as much. They have their ways. They have been doing it that way for years, so why change?” Changing current practices may be a struggle for some experienced teachers, but this is not always the case. The teacher in this study with the most teaching experience, 33 years, started using probeware five years ago. The teacher with the next most experience, 29 years, started using probeware last year after he was introduced to SPARK for the first time. Very experienced teachers, perhaps highly motivated ones, have integrated probeware late in their careers. Some experienced teachers do implement probeware and some do not. Similarly, not all new teachers use SPARK. Of the five teachers in the study with one year of teaching experience, two never used SPARK, two used it once or twice and one used it frequently. While teachers with less teaching experience seem to integrate SPARK slightly more, additional research with a larger sample size is necessary before any conclusions are drawn.

Educational Background

Educational background was the next characteristic explored. Were participants with masters' degrees more likely to use SPARK? Did it matter what the master's degree was in? Figure 10 summarizes the percent of teachers with various educational backgrounds who used SPARK.

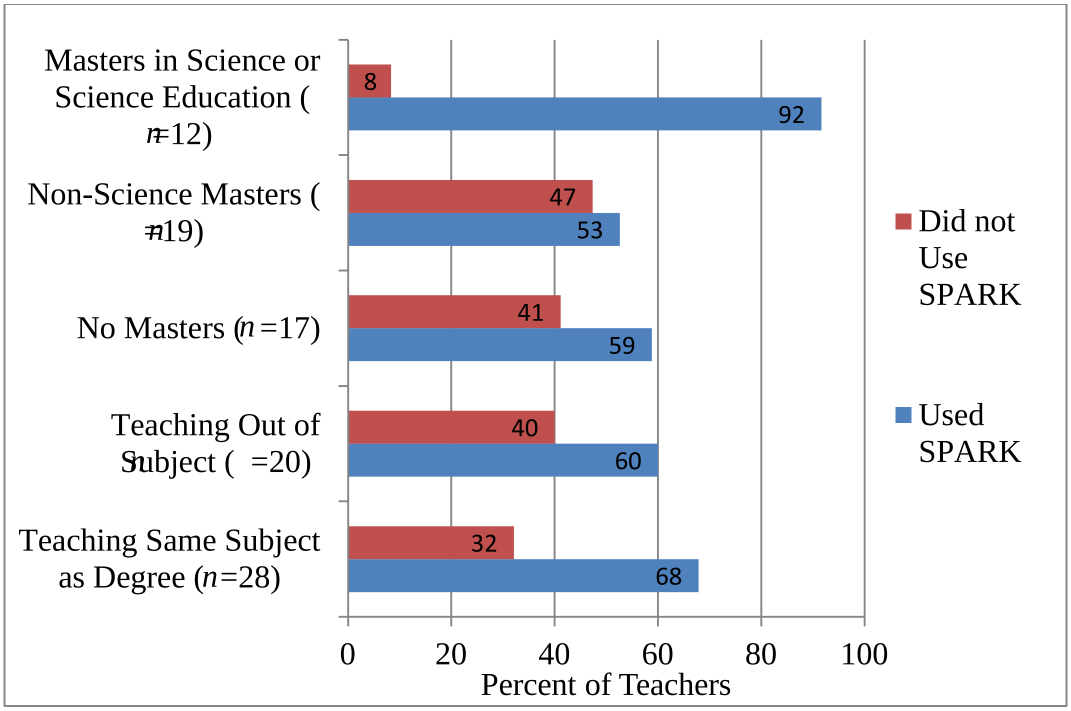

Figure 10. Educational Background and SPARK Use.

SPARK use differed depending on the type of master's degree the participant earned. Ninety-two percent of the participants with a master's degree in science or science education used SPARK. Fifty-three percent of the participants with a master's degree in counseling, administration, or education used SPARK. The group of teachers without a master's degree had a slightly higher percentage of teachers, 59%, use the SPARK. These results suggest that the participants with more education in science specific fields may have an easier time integrating the SPARK. This is likely because they have deeper understanding of content allowing them to understand the best ways to integrate the technology into their curriculums. Participants teaching the same science subject as their bachelor's degree used the SPARK slightly more than those teaching a science subject different than their degree, although the difference was not very large (68% compared to

60%). This data suggests that participants with stronger content knowledge may have an easier time using probeware. If this is the case, the SPARK workshop may need to include instruction on the content of the labs used in addition to the technical instruction on performing the lab.

Level of Science Course Taught

The next characteristic examined was the level of the science course taught. The teachers were placed into groups based on the level they taught: advanced, regular, and lower level. If a teacher taught more than one level, they were placed in more than one group. The percent of teachers who used SPARK in each course level is shown in Figure 11.

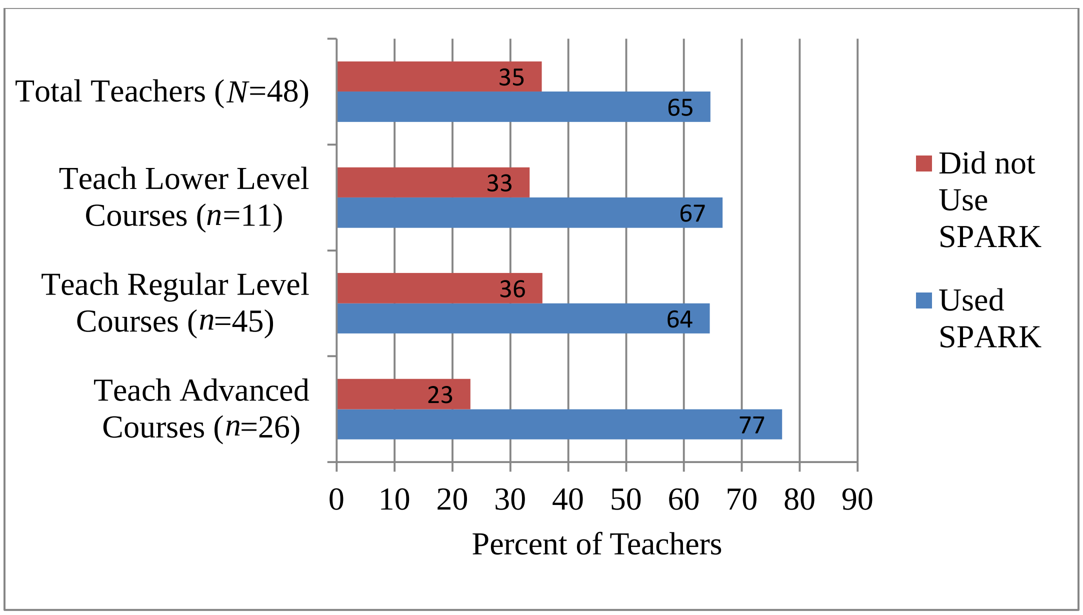

Figure 11. Level of Science Courses Taught and SPARK Use.

Of the participants who taught advanced level courses, 77% used SPARK. This was higher than both regular level teachers (64%) and lower level teachers (67%). Did the teachers who taught multiple levels use the SPARK in all the levels they taught? This question was answered using data collected from post-training interviews.

The teachers were asked which level course they used their SPARKs with and whether it was more appropriate for one level or another. The overall consensus was that the SPARKs were appropriate for all level students, but they were used more in advanced courses. One teacher, new to her school district, explained, “Honor kids get access to probeware, but the kids in my lower level classes have not seen them. Once I realized that, I have tried to incorporate them more into the lower level classes because I want them to have an equal opportunity.” This teacher recognized the SPARK was useful for all levels, but advanced students used it more often. Another teacher who had been using the SPARKs explained, “I use it in all my science classes. I would say the advanced placement use it more than the conceptual classes.” When asked why, this teacher explained, “To conceptual students the probeware is a black box. It is just a machine with a number. The advanced students have the theory behind it so they can explain why they get the numbers they see.” This teacher did not see probeware as a tool to help the lower kids, but instead as a tool to be used once a certain level of understanding had been achieved. Similarly, one of the teachers who had not used SPARK explained, “It [SPARK] would be really good for like data collection. You know getting more accurate data, especially with a quantitative data analysis lab. In a regular chemistry I don’t worry about this as much.” While some teachers recognize the value of using probeware for all students, other teachers perceive data collection and analysis as higher level skills that align better with the expectations of higher level science courses. This may explain, at least partially, why SPARK was used by teachers of advanced level courses more than teachers of regular level or lower level classes. This may be a characteristic that is worth bringing up during a workshop and getting teacher input on how to differentiate instruction with probeware.

Technology Use

Another characteristic researched was technology use. Did participants who frequently use technology with their students use SPARK more than minimal users of technology? In the pre-training survey (question #8) participants ranked their technology use on a scale of one (no technology being used) to 10 (lots of technology). Table 9 shows the average technology use prior to the PD workshop for participants who used SPARK and for those that did not.

Table 9
Technology Use and SPARK Use, N=46

Sample	**Mean Use of Technology Prior To the PD Workshop (SD)**
Used SPARK (*n*=30)	6.8 (2.2)
Did Not Use SPARK (*n*=16)	5.9 (2.0)

The participants who used SPARK had a higher technology use, however the difference in the values was statistically insignificant; $t(44)=1.3$, $p=0.09$. A trend did emerge when participants were grouped by minimal (three or less), average (four to six), and high (seven or higher) technology use. Figure 12 below shows the percent of minimal technology users, average technology users, and participants who reported using lots of technology.

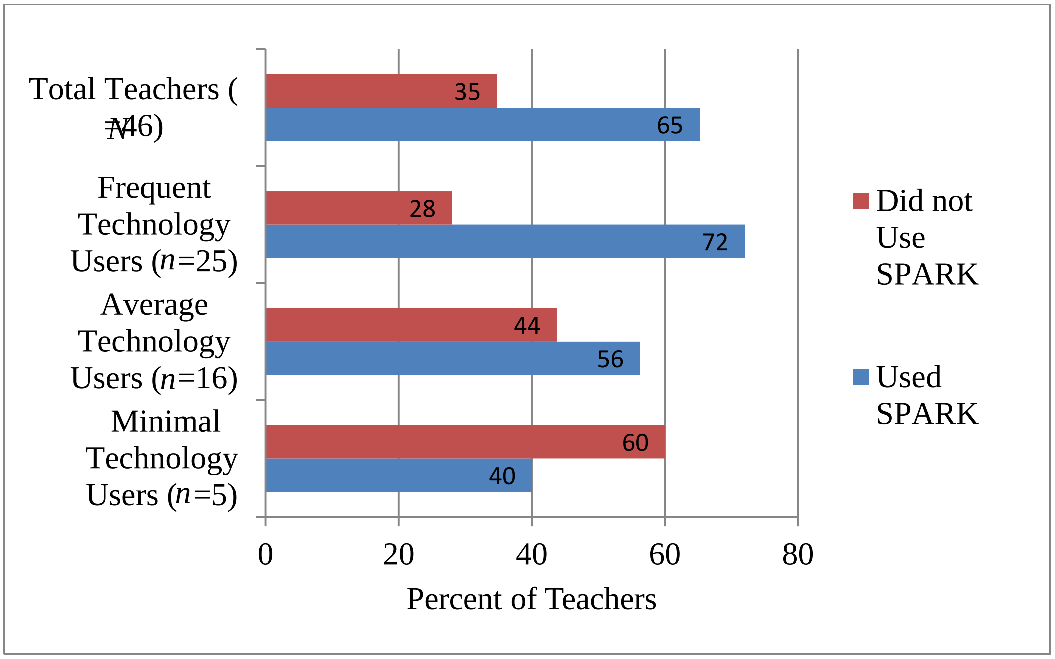

Figure 12. Amount of Technology Used and SPARK Use, (*N*=46).

Although the trend shows that participants using more technology prior to the PD workshop are more likely to use SPARK, there were exceptions in every group. In some cases minimal technology users implemented the SPARK and in other cases, participants who reported frequent use of technology never actually used SPARK. So while it appears that frequent technology users would easily integrate SPARK into their classrooms, it is not always the case.

<u>Lab Frequency</u>

The final characteristic investigated was the number of labs teachers typically had their students perform. The SPARK is a tool designed for use in the laboratory and therefore its use requires teachers to do labs. Were teachers who already performed a larger number of labs more likely to use the SPARK than those whose classes were less lab-based? The participants were divided into groups based on the average number of times their students engaged in lab activities each month. Figure 13 shows the percent of teachers in each group that used SPARK.

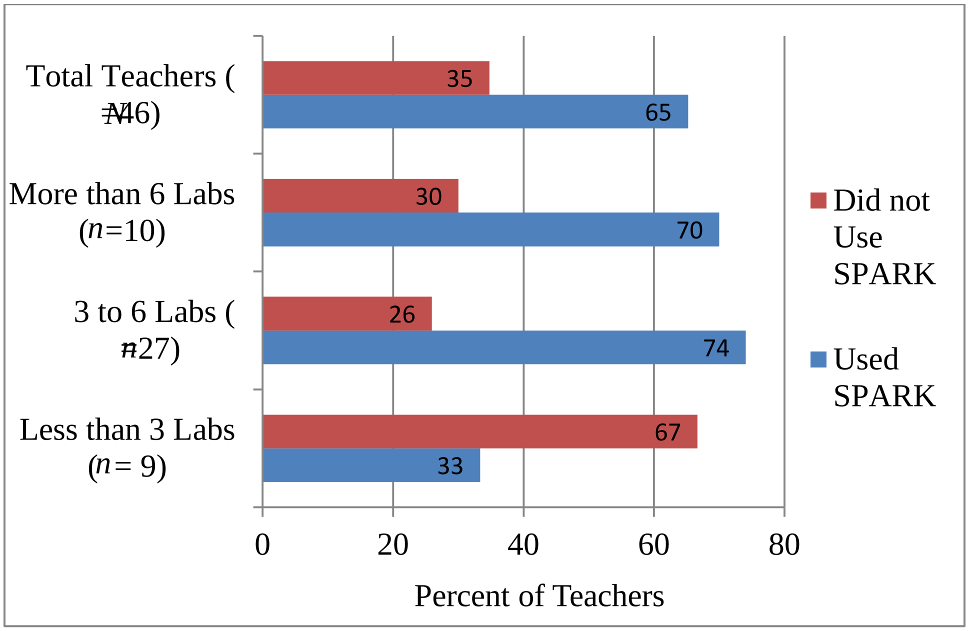

Figure 13. Frequency of Labs Performed per Month and SPARK Use, (*N*=46).

The results are similar to what we have seen for the other characteristics. Although performing three or more labs per month may promote SPARK usage, a given number of labs cannot guarantee a teacher will use SPARK. Three of the teachers who identified themselves as doing an average of more than six labs per month, never used the SPARK in the six weeks following the training. Conversely, three of the teachers who identified themselves as doing less than three labs per month did use the SPARK.

Was integrating SPARK into the science classroom easier for certain types of teachers? The data is not conclusive. Although there are apparent trends, the sample size is small and, there are exceptions to each trend. Participants in their first three years teaching had a 10% higher use of SPARK than teachers with more experience. Given the small sample size, additional research is necessary to determine if there is actually a trend. Out of all the teacher characteristics studied, educational background had the most significant trend. Over 90% of teachers with a master's degree in science education or a science-related field used SPARK. This was significantly different than the 65% of total participants that used SPARK. The data also suggested that advanced level teachers, teachers currently using more technology, and teachers who have students do labs more often, all tend to use SPARK more. In every group there were exceptions, so more research with larger sample sizes is needed. Can the workshop design be improved based on this data? If anything, the workshop may be geared toward advanced science teachers and teachers with a deep content knowledge of science. Including examples of how probeware helps lower level students learn science concepts may be useful. The facilitator should also be aware that the teachers may need a refresher on content knowledge, especially concerning how it relates to probeware use. The next section will further explore the effectiveness of the workshop design and how it can be improved.

Improving SPARK PD Workshops

This section reports on how the results of this study were used to improve future SPARK PD workshops. The SPARK workshop delivered in this study combined technical instruction on how to use the SPARK and allowed time to plan ways to implement the device in the classroom. First, the participants' feedback on the overall effectiveness of the workshop was analyzed and suggestions based on this feedback were proposed. Second, the technical content of the workshop was examined to determine if an appropriate amount of material was covered. Third, the implementation planning components of the workshop were investigated to ascertain their effectiveness. Finally, workshop improvements were recommended based on the data discussed earlier in the Data and Analysis section.

Six weeks after the workshop, participants were asked to reflect on the effectiveness of the training to help them implement SPARK in their classrooms. Most participants, including those who did not use SPARK, found the workshop effective. The results are shown in Figure 14.

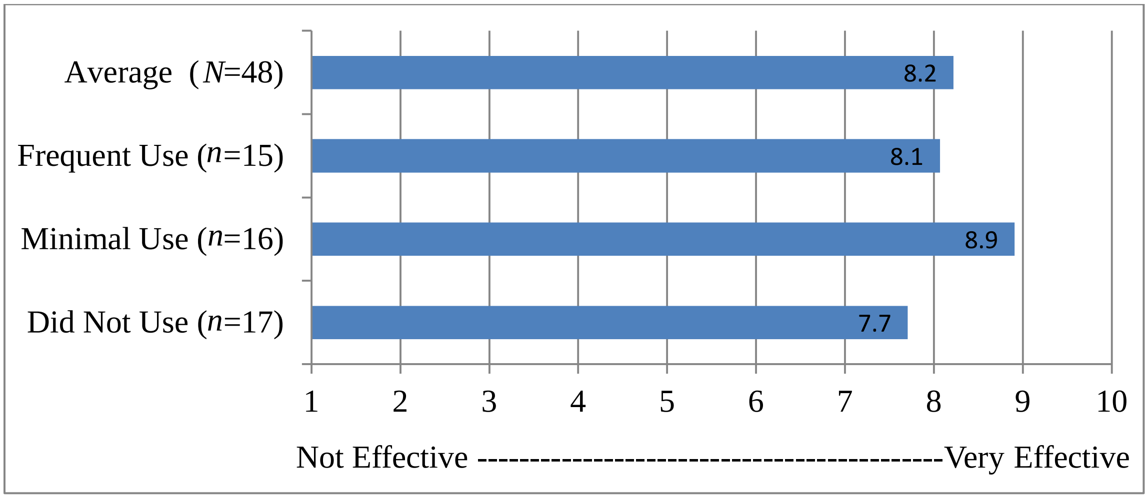

Figure 14. Effectiveness of the PD Workshop, (*N*=48).

Six weeks after the training the average participant rated the training as an 8.2 out of 10 on effectiveness. The participants who found the training most effective were the participants who used the equipment once or twice (minimal users). Participants who found the training least effective, rating it a 7.7 on a 10 point scale, were those who had not used SPARK. Could the training be altered to meet the needs of these participants more effectively? Figure 15 shows how the participants ranked the effectiveness of the workshop structure, content, and the facilitator.

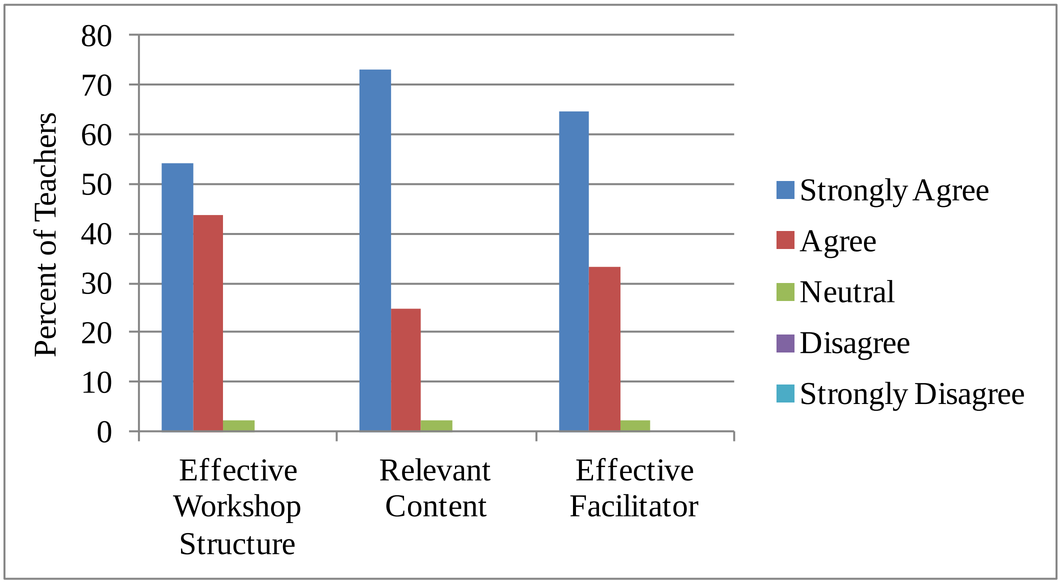

Figure 15. Effectiveness of Workshop Structure, Content, and the Facilitator, (*N*=48).

Ninety-eight percent of the participants strongly agreed or agreed that the structure of the workshop, content covered, and the way the workshop was facilitated was effective. The data shows that the workshop was effective for most participants, but that it could be improved. One SPARK user explained, “I think I would have gotten more out of it [the workshop] if I stepped into the next level of class.” This view was expressed by several of the experienced SPARK users. Another participant commented, “There was a lot of material covered quickly” and “I just needed more time to learn”. These comments suggest that the workshop could be improved by further supporting users on either end of the comfort scale. Participants already proficient with the SPARK were not challenged while some new SPARK users struggled to keep up with the group. Data on the length of the workshop, the level of difficulty, and the amount of information covered (Figure 16) further substantiated the claim that while of most participants’ needs were met, a few participants found the workshop to be too hard while others found it to be too easy.

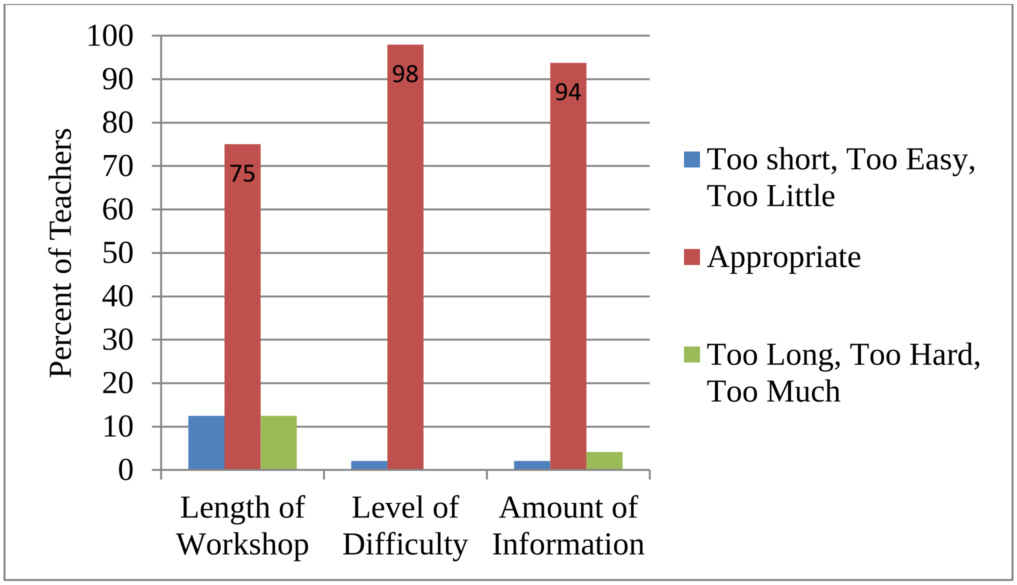

Figure 16. Length, Difficulty, and the Amount of Information in the Workshop, (*N*=48).

Although the participants' feedback indicates the workshop was effective, the fact that only 65% of participants used the equipment means there is room for improvement. Differentiated activities during the training could be incorporated to challenge the proficient users without overwhelming those new to the SPARK. This could be done in one of two ways depending on the facilitator's ability to communicate with workshop participants prior to planning the training. If communication is possible, the participants could fill out a pre-training survey prior to planning the workshop. Based on the results of the survey, the facilitator could design activities specifically for different groups of participants. If communication is not possible, generic differentiated activities could be created for the workshop and used as needed. Additionally, the facilitator could have the participants fill out a short survey midway through the training to determine if participant expectations and needs were being met. The facilitator could adjust the afternoon activities as needed based on the participants' responses.

While most participants found the workshop effective, 35% of workshop participants never used SPARK in the six weeks following the workshop. Would changing the amount of technical instruction facilitate a higher use of SPARK? If so, what needs to be added or removed? At the end of the workshop, 94% of participants reported being ready to use SPARK in their classroom (Figure 5) and on the post-training survey 94% of participants reported that the amount of information covered in the workshop was appropriate (Figure 16). Furthermore, in the post-training survey only 4% of participants cited, "I am not confident using SPARK" as a barrier that prevented them from using the device. The data indicates that a sufficient amount of technical instruction was provided.

Could technical content have been removed? Three main skills were taught during the training: data collection, data analysis, and saving/transferring files. Data collection and analysis must be taught at a basic level to use the SPARK. Saving and transferring files, however, is only needed if the teachers have their students enter their answers into the SPARK and submit the labs electronically (either as a SPARK file or as an electronic journal). This process can be avoided if students collect data on the SPARK, but write their results on a piece of paper. In the post-training survey, the participants were asked how they collected student work after a SPARK activity. Figure 17 shows the percent of teachers who used each of these methods. The participants were allowed to select more than one method.

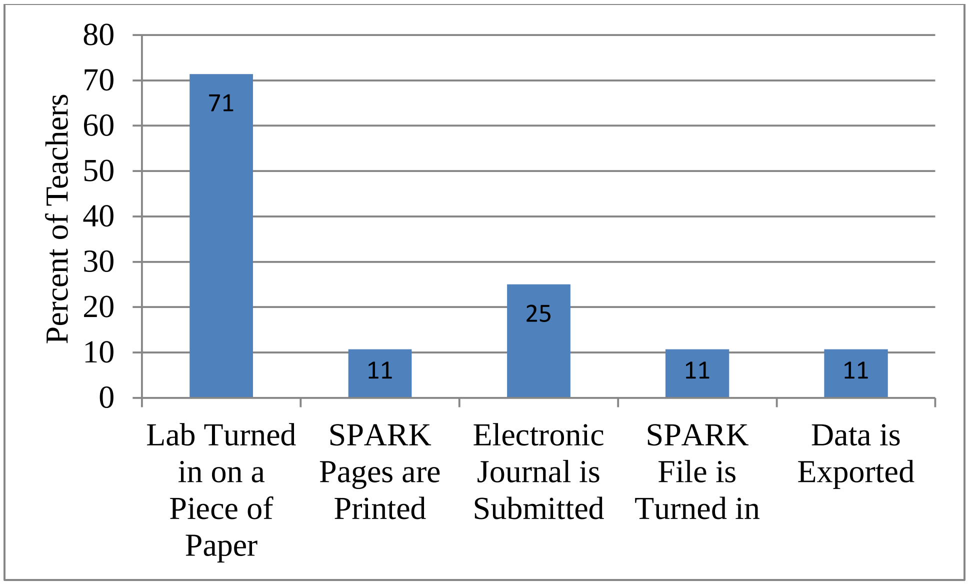

Figure 17. Ways Teachers Have Students Submit Work Done Using SPARK, (*N*=28).

The majority of teachers (71%) had their students submit their work on a piece of paper. The workshop facilitator encouraged participants to use this method with their students, but it was only practiced once. The rest of the time, the participants created electronic files. The disparity between how teachers used SPARK and what was emphasized in the workshop suggests that file transfer skills should be removed from the morning portion of the training and introduced later in the day as an option for participants who are interested. The only time file transfer should not be eliminated is when the school or district requesting the PD workshop already has a process for collecting student work electronically. For all other schools, eliminating technical instruction on file transfer would allow participants to spend more time on mastering the technical skills required to collect and analyze data and focus more on how to implement SPARK. Additional research is needed to determine if more teachers would use SPARK if electronic file transfer were eliminated from the training.

The next aspect of the workshop examined was the effectiveness of the implementation planning. While nearly all of the participants left the workshop feeling comfortable with the technology, not all of the participants used SPARK with their students. This data indicates that getting workshop participants to use SPARK is more difficult than getting them to be comfortable using the technology. The PD workshop delivered was designed to help participants integrate SPARK by doing lab activities that related to the teachers' curriculum, planning three ways they would use SPARK following the workshop (SPARK action plan), and having the participants present the activities they did to practice "teaching" with the technology. How effective were each of these components in helping the participants implement SPARK and how could the implementation part of the training be improved?

Having the participants learn the SPARK by practicing labs related to the teachers' curriculum was identified by the teachers as being very effective. First, 98% of the teachers agreed or strongly agreed that the content was relevant to their classes (Figure 15). Second, 90% of the participants selected lab activities as the most helpful aspect of the training (Figure 18).

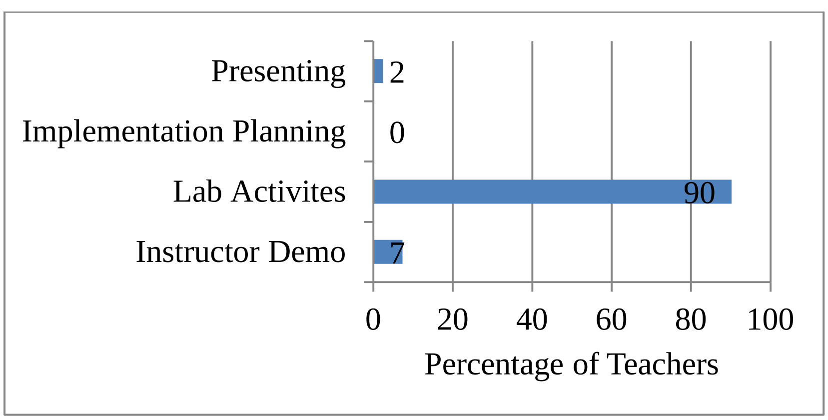

Figure 18. Most Helpful Aspect of the Workshop, (*N*=41).

Finally, all of the participants included at least one lab activity that was practiced during the workshop on their SPARK action plan. When asked how to improve the workshop many teachers responded with comments such as, “More time to practice different labs,” and, “More guided labs.” This is a key piece of the workshop that should continue in future trainings. One way the workshop could be made more effective is by having the workshop participants submit a list of lab activities that they would like to practice prior to the planning of the workshop. This way, the participants would start their implementation planning prior to the PD workshop. This information could be collected using a pre-training survey as suggested earlier.

A key component of the implementation portion of the workshop was the SPARK action plan. Each participant planned how SPARK would be implemented by writing down three specific activities they would use following the workshop. The planning required that the participants select how to use SPARK (demonstrations, small group activities, or independent lab work), which sensors to use, and which standard their activity would cover. None of the participants selected implementation planning as the most helpful part of the workshop (Figure 18). Furthermore, 50% of the participants never followed any of their plans (Figure 6). Does this mean it was not a valuable tool? Was it helpful enough that it should be used in future trainings? To answer this question, data from SPARK users was analyzed.

One benefit of the SPARK action plan was that participants used SPARK for more than just independent student labs. Figure 19 compares how participants planned to use SPARK (in their action plans) with how it was actually used.

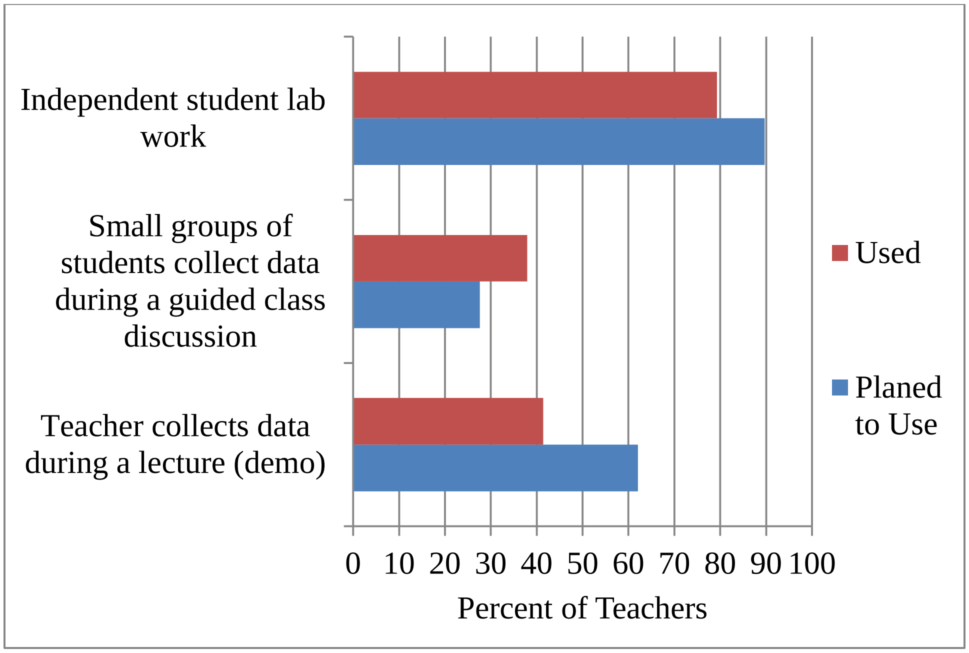

Figure 19. Planned SPARK Use Compared to Actual Use, (*N*=28).

While most teachers (80%) had their students perform labs, nearly 40% of the teachers also used SPARK in small group discussion and as teacher-led demonstrations. Some workshop participants only used SPARK by doing classroom demonstrations. This technique works well with traditional style teachers, teachers with limited access to equipment, and teachers who worry about classroom management because it allows them to ease into probeware use. Despite this advantage, demonstrations were used less than participants had planned. This was likely due to the fact that the participants did not have the SPARK software set up on their computers and thus could not project the data for the entire class to see. Future training can be improved by ensuring that the equipment is installed and all the necessary pieces of equipment are connected prior to the workshop. This can be done by working with the school's technology department and by providing support materials on PASCO's website that guide the teachers through this process. Even with these technical challenges, the percent of teachers implementing SPARK would likely have been less if the teachers had not been introduced to the option of demonstrations on the SPARK action plan.

Having students collect data during class discussions is another way to ease into probeware use because it does not require a lot of preparation or time and the teachers can walk their entire class of students through an activity. The live data displays can promote lively class discussions and each group of students can contribute their own data. While this method was modeled in the workshop, future training could be improved by explicitly discussing the benefits of this method instead of simply modeling it. Similar to demonstrations, it is likely that small group discussions increased the number of times SPARK was used because it was included on the SPARK action plan.

In addition to providing ideas for how to use SPARK, the SPARK action plan also facilitated the use of SPARK. Of the participants who used the SPARK, 77% (24/31) reported using one or more activities from their SPARK action plan. Of the seven participants who did not use their action plan, three reported they had not started their plan yet and the others explained that they used SPARK, but not in the way they had planned. Several participants explained that they still planned to do the activities, but they had not gotten to that topic yet. While others described how they thought the lab would fit, but they decided to save the activity for later in the year. Other participants included activities for units or activities they already finished.

Based on the data collected, the SPARK action plan was effective for some participants, but some fundamental changes could improve its effectiveness. First, the workshop facilitator needs to emphasize the importance of timing. It is crucial that the participants focus on activities that help them cover the curriculum they will teach in the six weeks following the workshop. To help with this, the SPARK action plan was revised to include the subtitle “How will you use SPARK in the next six-weeks?” and a back side was added that included space for participants to list activities they wanted to do, but did not fit into the next six weeks. Second, some of the PASCO jargon that the participants did not understand was removed. Third, a section on the standard/unit that the activity taught was included to help the participants see the connection between the activity and their curriculum. Finally, for each activity listed the participants were asked to brainstorm barriers that may prevent them from doing this activity and how they would overcome them. A revised version of the SPARK Action Plan is found in Appendix K.

Another change that could increase the effectiveness of the SPARK action plan is to incorporate a form of accountability. This could be done between the workshop facilitator and the science coordinator organizing the workshop. Ideally, six weeks after the workshop the teachers would meet again and share their experiences using SPARK. This could be part of a staff meeting, a professional learning committee, or a follow-up workshop. Additional support should be provided to those teachers who need it and additional time should be allotted for further curriculum integration. Ideally probeware based activities would be integrated into each course’s scope and sequence.

The final component of the workshop design promoting implementation of SPARK was the presentations. Previous research indicated that technology integration required teachers to practice teaching with their newly acquired skills (Valanides and Angeli, 2008). Only one participant, 2%, selected presentations as the most helpful part of the workshop (Figure 18). This participant explained, “It was helpful for each of us do different things and then present. It was time-consuming for them. But then you can see all the different ways you can use it in your classroom." This teacher recognized the benefit of learning various ways the SPARK could be used, but did not comment on needing to practice with the technology in a "teaching" environment. The facilitator observed a few additional benefits as well. For example, the presentations allowed the participants to teach one another new features, encouraged discussions about science content, and facilitated debate about the best way to customize the activities for their students. Based on these observations, the presentations are an effective component of the workshop.

Finally, the SPARK PD workshop could be improved by incorporating the information this research revealed regarding school environments that promote probeware use and barriers that impede it. Prior to the workshop, the facilitator should work with the workshop organizer to get the equipment installed, updated, and organized prior to the workshop. This will enable the workshop participants to use the SPARK the day after the workshop. During the workshop the facilitator should share the most common barriers teachers face in implementing SPARK and lead a discussion about how these barriers can be overcome. Additionally, the facilitator should ask questions and strongly encourage the workshop participants to think about the effectiveness of probeware labs, where they should be incorporated into the curriculum, and how they can be customized to meet individual student needs. Being aware of potential pitfalls may help some participants write realistic action plans for using SPARK in the weeks following the training.

Overall, the SPARK PD workshop was effective in improving comfort and facilitating the use of SPARK in the classroom. Most of the teachers enjoyed and benefited from the workshop. With a few additional changes the workshop can result in greater comfort with SPARK and facilitate a greater use of SPARKs in the classroom. The main changes were

- gathering information from workshop participants prior to workshop planning;
- including sessions with differentiated activities;
- reducing the emphasis on electronic filing sharing;
- revising the SPARK action plan handout; and
- facilitating a discussion on barriers teachers face implementing SPARK in their classrooms.

A revised workshop agenda outlining the changes mentioned is included in Appendix J. These changes will create an even more effective PD workshop for PASCO's customers as they take on the challenge of becoming proficient SPARK users.

INTERPRETATION AND CONCLUSION

The goal of this action research was to determine the effectiveness of a six-hour SPARK PD workshop on the participants' comfort using SPARK and helping the participants implement SPARK in their classrooms. The effectiveness was assessed by analyzing changes in participant comfort level using SPARK, determining how often participants used SPARK in the six weeks following the workshop, and comparing how the participants' plans for using SPARK compared to how it was actually used. The data collected was further analyzed to determine how school environment affects SPARK usage, to identify barriers teachers faced implementing SPARK, to identify common characteristics of teachers that used the SPARK in their classrooms, and to determine ways to improve the effectiveness of future PD workshops. The data indicated that the six-hour SPARK PD workshop had a positive impact on participants. The workshop effectively increased participant comfort with SPARK and facilitated the use of SPARK in the classroom, but the workshop did not leave participants 100 percent comfortable using SPARK software and it did not result in all participants using SPARK in their classrooms. This section summarizes the effectiveness of the six-hour PD workshop, outlines the characteristics of schools and teachers that implement probeware, summarizes ways to improve the SPARK PD workshop, provides recommendations for schools interested in training their teachers on probeware use, and ends with a list of additional research questions.

The first research question explored how the participants' comfort level with SPARK changed after the after the six-hour PD workshop and six weeks later. Prior to the workshop, the participants reported an average comfort level with SPARK as 3.3 on a 10 point scale. At the end of the workshop, the average comfort level increased 3.8 points to 7.1. Six weeks later the average participant's comfort had further increased to 7.3. The workshop effectively increased the comfort level of most participants. The increase in comfort with SPARK varied based on the participants pre-workshop comfort level. Participants new to SPARK increased their comfort the most (5.6 points), while intermediate users had a significant, albeit smaller increase of 2.7 points, and advanced users maintained or in some cases reported a lower comfort level with SPARK. While most participants reported an increase in their comfort with SPARK, very few reported a comfort level of 10 out of 10 recognizing that they still had more to learn and needed time to practice. This means that the participants did increase their comfort level with SPARK as a result of the workshop, but that the technology had not been mastered.

In addition to increasing comfort using SPARK, the effectiveness of the workshop depended on how participants used SPARK in their classrooms following the workshop. The second research question investigated the frequency of SPARK use in the six weeks following the workshop and how participant comfort using SPARK, its planned use, and the school environment affected how often SPARK was used. In the six weeks following the workshop 65% (31/48) of workshop participants used SPARK in their classrooms. The SPARK was used frequently (three or more times) by 31% (15/48) of workshop participants and was used minimally (once or twice) by 33% (16/48) of workshop participants. In post-training surveys and interviews most participants attributed their use of SPARK to the workshop. In fact, the participants ranked the effectiveness of the training to help them implement SPARK at an average of 8.2 out of 10. The minimal SPARK users reported the effectiveness of the training slightly higher than average, at 8.9, suggesting that they may not have used SPARK if they had not attended the workshop. This data confirms that the PD workshop effectively facilitated the use of SPARK in the classroom for some participants. The fact that not all participants used SPARK and that 33% of participants used the device minimally suggests that there may be ways to improve the effectiveness of the workshop to facilitate SPARK use in the classroom.

To improve the workshop, it is necessary to understand why some participants used the SPARK after the training while others did not. The first variable examined was participant comfort with using SPARK software. The difference in average comfort level with SPARK between participants who used SPARK (7.3/10) and those who did not (6.7/10) was insignificant. This means comfort using SPARK software cannot explain why some participants used SPARK while others did not. It also means that feeling comfortable using SPARK software does not guarantee that SPARK will be used. For a PD workshop to facilitate SPARK use in the classroom it has to do more than make the participants feel comfortable with the software. Six weeks after the workshop the participants who had used SPARK reported an increase in comfort (7.8/10) while the comfort level for non-users decreased (6.3/10). This means that using SPARK within six weeks after the workshop increases a teacher's comfort level with the device while not using SPARK causes a decrease in comfort level.

In addition to teaching how to use the SPARK, the PD workshop also guided participants on a variety of ways to use SPARK in their classrooms. During the workshop each participant created their own SPARK action plan outlining three specific activities they would do with their students. At the end of the workshop, 83% (39 out of 47) of the participants agreed or strongly agreed that they would follow their plan, 15% (7/47) were neutral, and one participant said she would not follow her plan. Furthermore, 94% of participants (44 out of 47) agreed or strongly agreed they were ready to use SPARK with their students. This data shows that most participants left the workshop planning to use SPARK and feeling ready to do so. In reality, 24 of the 48 participants (50%) followed at least part of their SPARK action plan, but only two of these teachers completed the entire plan. There were 31 participants who used SPARK with their students and 24 of them (77%) used at least one activity they had listed on the action plan they created during the workshop. For the participants who used SPARK, the action plan was an effective tool in helping them implement SPARK. Twenty-five percent of the participants, however, had acknowledged being ready to use SPARK, but never ended up using it. In these cases being comfortable with the SPARK and having a plan on how to use SPARK in the classroom was not enough to get the participants to use SPARK with their students.

Another variable that affected SPARK usage was the school environment. Workshop participants surrounded by positive colleagues working together were more likely to use SPARK. During the workshop, and later at their schools, these teachers provided support to each other as they implemented SPARKs in their classrooms. In addition to a supportive environment, organization and upkeep of the equipment was a critical component of school environments that promoted the use of SPARK. The SPARK software was installed on all computers, the equipment was inventoried, and there was a check-out system in place so teachers could easily access the equipment when needed. The next component of the school environment that fostered SPARK usage was a clear connection between the curriculum taught and the probeware owned. Workshop participants who understood how the SPARK activities fit into their course standards and district requirements were more likely to use SPARK. Additionally, participants who owned the probeware that matched their curriculum were also more likely to use the equipment. Finally, workshop participants who came from schools with longer class periods (68 minutes or 90 minutes) were more likely to use SPARK than participants who had shorter class periods (50 minutes). While a six-hour workshop cannot create these school environments, the workshop facilitators should work with the schools and districts to promote as many of these characteristics as possible.

The third research question investigated teacher characteristics to determine if certain types of teacher were more likely to use probeware. The sample sizes in this portion of the study were too small to draw any significant conclusions, but the data suggests workshop participants with the following characteristics used the SPARK the most.

- New teachers (less experience)
- Teachers with a master's degree in science education or a scientific field
- Teachers of advanced level courses
- Teachers who already use lots of technology in their classroom
- Teachers who have their students perform three or more labs per month

Each of these characteristics had exceptions. There were teachers with more than 25 years of teaching experience that used SPARK and there were new teachers who did not use SPARK. There were teachers who reported using very little technology, yet they used SPARK. Similarly, there were teachers who reported frequent use of technology, but did not use SPARK. The characteristic with the most significant difference was educational background. There were 12 participants who held masters' degrees in science education or a scientific field and 11 (92%) of them used SPARK. While only 53% (10/19) of participants with a non-science masters' and 59% (10/17) of participants without a master's degree used SPARK. While there appears to be some possible trends, additional research with larger sample sizes is needed before the trends can be confirmed.

The last research question examined how the results of this study would impact the design of future professional development workshops. While most of the participants reported that the current workshop design was effective, several ways to improve the workshop were identified. First, a pre-training survey will be used when possible prior to planning the workshop. The survey will assess participant comfort level with SPARK, goals participants would like to accomplish, and specific lab activities they would like to do with probeware. Second, to accommodate the needs of participants with different skill levels, sessions with differentiated activities will be included. Third, instruction on electronic file sharing will be moved to later in the day and only provided for participants who plan on collecting electronic files from their students. The rest of the participants will continue to use the SPARKs to collect data, but have their students submit their lab reports on paper. Fourth, a discussion on barriers teachers face when implementing SPARK will be added. Finally, the SPARK action plan handout was revised to clearly focus on the six weeks following the workshop; to include the standard being taught to emphasize curriculum integration; and to include a place for teachers to consider the barriers that may prevent them from doing these activities and how they can overcome these barriers. With these changes, the effectiveness of the six-hour workshop will improve, resulting in more teachers using SPARK in their classroom.

Recommendations for Schools Considering Probeware Integration

In addition to improving the SPARK PD workshop, the results of this study provide schools and school districts interested in probeware integration with a few recommendations. First, probeware should be purchased based on your curriculum standards. Make sure that the current standards and school district expectations lend themselves to probeware use. Also, make sure that each piece of equipment can be effectively used to teach part of the curriculum. Second, have a plan in place for organizing, installing, and maintaining the probeware and its corresponding software (including updates). This plan should include how the probeware will be accessed and shared among all the teachers. Third, a six-hour professional development workshop is a great way to kick-start probeware use by increasing teacher comfort with the technology and getting about 65% of teachers to use it in the classroom. Be forewarned, however, that a six-hour training will not get all teachers using probeware and the teachers that do not use probeware will start to lose their comfort with the technology in as little as six weeks. The effectiveness of a six-hour workshop can be extended as part of a larger professional development plan for probeware integration. Teachers who become frequent probeware users as a result of the six-hour workshop can be recruited to support and train the other teachers. All teachers need time to practice probeware activities and find the best way to integrate them into their curriculums. A PD workshop should be provided after the equipment has been installed and organized, and prior to a four to six week teaching period that includes standards effectively taught with probeware. Finally, probeware integration is most successful in schools with positive and supportive teachers who work together to learn and integrate probeware.

Further Research

In the process of collecting and analyzing the data from this action research project, many questions were left unanswered. For example, what happened to the participants use and comfort with SPARK after 12, 18, and 24 weeks? How about a year later? Did some of the non-users start to use SPARK? Did any of the minimal users become frequent users? Is there a relationship between competency with the SPARK software and comfort? In this study, the participants self-assessed their comfort with SPARK, but comfort is not the same as competency. Furthermore, this study simply assessed whether or not workshop participants used SPARK and not on the effectiveness of how SPARK was used. It would be interesting to find out what percent of teachers used SPARK to improve student learning. Additionally, some of the research collected in this report had small sample sizes and thus conclusions could not be drawn. More research is needed on whether certain teacher characteristics, such as educational background and teaching experience, make it easier for certain types of teachers to implement probeware. The sample size was also too small to draw any conclusions about how the type of training affects probeware use. For example, is it more effective for a district with multiple schools to have school-wide, multi-subject trainings or is it better to have subject specific trainings? Is there and ideal number of participants to have at a training? Is probeware used differently in some science subjects than in others? How would these differences change the structure and design of the workshop? There are many questions related to probeware integration and effective professional development workshops that need to be researched before a clear understanding of probeware integration is established.

Conclusion

To conclude, the one day professional development workshop that integrated technology instruction with implementation planning was effective at increasing participant comfort using the SPARK software and did facilitate the use of probeware by 65% of the workshop participants. The integration of SPARK was most successful in schools with staff who worked together and supported one another and in schools that had the equipment installed, organized, and easily accessed. The PD workshop is an effective addition to a professional development plan that includes training teachers to integrate probeware.

VALUE

Completing this capstone project has been an incredible process filled with frustrations, discoveries, and joy. It has helped me to understand my job as a professional development trainer; it has given me new ideas on how I can do my job better; and ways that PASCO can better meet the needs of our customers. Through this process I have gained a deeper understanding of the challenges schools and teachers face when they implement technology to improve science instruction. The experience of trying to effect change in the practices of teachers also gave me some insight into the challenge of education reform.

This capstone project forced me to take a step back and analyze my role as a PASCO training developer. Through this process I came to realize that my role as a facilitator of professional development workshops was so much more than simply training the participants on how to use SPARK. The teachers needed to understand how the SPARK system would help them teach and help their students learn. They needed ideas on ways to integrate the technology into their curriculums and how to organize and manage the equipment. In some cases the teachers needed help learning the science content, and in other cases they needed instructional strategies.

I have made four major changes to the way I do my job at PASCO as a result of this action research process. First, I use pre-training surveys whenever possible to learn as much as I can about my participants before I plan the workshop. Second, the activities I select for the training all relate to topics the teachers will cover in the weeks immediately following the training. Third, I work with the schools to get all of the technology set up for the teachers before the training. And finally, I am working on ways to differentiate instruction on the day of the workshop.

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APPENDICES

APPENDIX A

SAMPLE WORKSHOP AGENDA

PASCO SPARK Training
August 22, 2011

Goal

To become comfortable using the SPARK Science Learning System to collect and analyze probeware data and to perform experiments ready for your science classroom.

Agenda

SPARK Measurement Essentials

7:30 Introductions

7:45 SPARK Science Learning System Overview
We'll discuss how the SPARK Science Learning System is designed to collect and analyze various types of data.

8:00 SPARKlab: Alka-Seltzer in Fruit Juice
Together we'll open and walk through a sample SPARKlab. You will practice collecting data and saving your data in the Journal.

8:30 Data Analysis and Conclusions
We will share our data, draw conclusions, and discuss further experimentation that could be done with this topic.

8:45 SPARK Implementation Guide
How will you implement SPARK with your students? We will discuss the various decisions you will have to make when deciding how to implement SPARK in your classroom.

9:00 **Break**

9:15 Paper Labs with SPARK
Build your own data displays to collect data on the SPARK as you work through a paper lab from the choices available on the back of the agenda.

10:15 Analyze Data Presentations
You will transfer your data to the presenter's computer and analyze the data you collected as if you were doing this with your students. In doing so, you will teach the analysis tools you learned to your fellow teachers.

10:45 SPARK Action Plan
Spend 15 minutes to write down the first couple of ways you plan to implement SPARK with your students.

11: 00 **Lunch**

12:00 Science Lab – Full Paper lab or SPARKlab
Practice a lab that you will implement with your students within the next couple of weeks. Learn the different sensors and SPARK features required for this activity.

1:00 Presentations

Present the lab you completed to the group. Include the purpose of the lab, an overview of the procedure, sample data, and an analysis of the data. End the presentation by demonstrating new features you learned on SPARK and your ideas for pre-lab and post-lab activities.

1:30 Science Demo, Group Discussion Activity, or Group Challenge

Practice a lab demo, a group discussion activity, or a science challenge that uses SPARK software to teach a specific science concept.

1:50 Presentation

Present your activity to the group using SPARKvue software.

2:10 SPARK Action Plan

Write down at least 3 ways you will implement SPARK in the next 4-6 weeks. Include how you will collect the student's work and what you will have to prepare before doing the activity.

2:20 PASCO Resources and Evaluation

This time is for any final questions on the SPARK or its implementation and to evaluate the training.

2:30 **End of Training**

Recommended Labs:

Subject	**Lab Name**	**Type of Lab**	**Sensor(s)**
Chemistry			
	Percent Oxygen in Air	SPARKlab	Pressure
	Intermolecular Forces	SPARKlab	Temperature
	Solutions: Electrolytes and Non-Electrolytes	Paper lab	Conductivity
	Gas-Laws	Paper lab	Pressure
Biology			
	Role of Buffers	SPARKlab	pH
	Exploring Microclimates	SPARKlab	Temperature
	Energy content of food	Paper lab	Temperature
	Exercise and Heart Rate	Paper lab	Exercise Heart Rate
Physics			
	Archimedes Principle	SPARKlab	Force Sensor
	Newton's Second Law	SPARKlab WV	Force Sensor
	Hook's Law	Paper lab	Force Sensor
	Acceleration	Paper lab	3-Axis Accelerometer

APPENDIX B

SPARK IMPLEMENTATION GUIDE

SPARK Implementation Guide

Integrating probeware into science curriculum improves learning when it is implemented effectively. This handout guides you through the process of deciding how to integrate SPARK effectively into your classroom.

1. **Pick an activity and an appropriate sensor.**
   Probeware is a tool, and like all tools it will help you in some situations, but not all. Pick an activity that allows you to teach a standard effectively.

    - What type of activity will you use?

Demonstration	PASCO SPARK lab	Customized lab
Class discussion with group data collection	PASCO Paper lab	Other

    - Why will using probeware help you teach this topic better and/or help your students learn this topic better than without probeware?
    - What sensor(s) is used in the activity?
    - Will the activity be graded?

2. **Decide if students will turn in their work electronically or on paper.**

    - Will each student turn in a lab report or will each group turn in a lab report?
    - Will students record their answers on SPARK or a separate piece of paper?
    - Will students use SPARK for data analysis or will they export data to another program (such as Excel)?
    - If you collect students' work electronically, how will you have students turn it in?
        - SPARK file
        - SPARK Journal
    - Where will you have students save their files?
        - On the SPARK.
        - On a USB flash drive.

3. Create a plan to introduce the activity (pre-lab).

What do you need to show the students before they begin?

- **Content**
  - What concepts and/or vocabulary do the students need to understand?
  - What do you expect students to be able to do at the end of the activity?
- **Sensor**
  - What does the sensor measure?
  - Are the students familiar with the sensor measurement units?
  - Does the sensor need to be calibrated? If so, how?
- **Procedure and Technology**
  - Define procedural steps that are tricky or important to do in a correct order.
  - What specific skills on the SPARK (building a graph, making a prediction, etc.) do students need to have? Can these be pre-taught?
  - What other expectations do you have for the students?
    - Will they save their files? Where?
    - Will they turn in an electronic version of the lab? How?
    - What if they do not finish the lab?
- **When will you introduce the lab?**
  - Day before the lab or the day of the lab (will there be enough time)?
  - Will you assign a pre-lab assignment for the students?

4. Plan a post-lab discussion.

Using probeware often reduces data collection time allowing students more time to process and understand the lab. There are many ways you can facilitate student understanding:

- Have students compare their predictions to the lab results.
- Discuss different sources of error.
- Compare data among groups in the class and identify reasons for any discrepancies.
- Create a class data set by having each group export their data to a shared Google Docs files and analyze the data as a class.
- Repeat experiments to see if results are reproducible.
- Have students perform extension activities or inquiry investigations.
- Project data sample data for the class to see and have the students interpret the results and draw their own conclusions.

Other considerations:

- What materials do you need to prepare for the lab?
- What obstacles could make implementing the probeware difficult?
- How will you overcome each of these obstacles?

Electronically Managing SPARK Files and Journals

Options for saving files:
Select the share icon to access these choices.

Lab Pages (view .spk files using SPARKvue)		**Journal** (view images electronically or printed)	
SAVE FILE AS	Save in a folder on the SPARK.	**PRINT**	Prints two snapshots per page.
	Save on a USB flash drive.	**EXPORT**	Save on a USB flash drive.
SUBMIT	Save in a hidden folder on the SPARK.	**SUBMIT**	Save in a hidden folder on the SPARK.

Ways to transfer electronic files from SPARK to your computer:

- **Use a USB Flash drive**– transfer the files from the SPARK to a USB flash drive and then from the flash drive to your computer.
    - Select the folder/battery icon.
    - Select manage files.
        - COPY FILES– leaves one copy on the SPARK.
        - MOVE FILES– the files is moved to the USB and is no longer on SPARK.
        - DELETE FILES– deletes the files completely.
        - COLLECT FILES – copies the files that have been submitted.

- **Use a USB to mini USB cable**– attach each SPARK to your computer using this cable and transfer the files from the SPARK to your computer.
        - Select File System on the SPARK.
        - Open the SPARKsls storage device on your computer.
        - Copy the files from the collection or saved work folders.

APPENDIX C

SPARK ACTION PLAN

SPARK Action Plan

In which class will you implement SPARK? ___________________________________

SPARK Activity #1: ________________________________ Date: _____
What sensor is used?

Which of the following best describes your activity?

☐ Lecture/Demo ☐ Class Discussion ☐ PASCO Paper lab
☐ PASCO SPARKlab ☐ Customized SPARKlab ☐ Customized Paper Lab

How will students turn in their work? ☐ Paper ☐ Electronically

What needs to be prepared?

SPARK Activity #2: ________________________________ Date: _____
What sensor is used?

Which of the following best describes your activity?
☐ Lecture/Demo ☐ Class Discussion ☐ PASCO Paper lab
☐ PASCO SPARKlab ☐ Customized SPARKlab ☐ Customized Paper Lab

How will students turn in their work? ☐ Paper ☐ Electronically

What needs to be prepared?

SPARK Activity #3: ________________________________ Date: _____
What sensor is used?

Which of the following best describes your activity?

☐ Lecture/Demo ☐ Class Discussion ☐ PASCO Paper lab
☐ PASCO SPARKlab ☐ Customized SPARKlab ☐ Customized Paper Lab

How will students turn in their work? ☐ Paper ☐ Electronically

What needs to be prepared?

APPENDIX D

SAMPLE CHALLENGE ACTIVITIES

Challenges

1. A student places a marshmallow inside a syringe. What happens to the pressure (and to the marshmallow) when the volume of air in the syringe is decreased?

2. How does pH change if CO_2 is added to water?
   Does more CO_2 cause a greater pH change?

3. Without using a calculator, mental math, or paper and pencil, convert the following temperatures:

   10 °C to °F
   180 °F to °C
   70 °F to °C
   310 K to °F

4. When you go up in altitude, what happens to air pressure?

5. Pretend that the tip of the temperature probe is a polar bear. Your challenge is to use Crisco to produce a polar bear that can withstand freezing Arctic Ocean water temperatures the best. Remember to test each polar bear that you make on your SPARK and annotate (label) each run. HINT-you might want to do a “control run” with the temp probe in the ice water so you have a good comparison.

6. Are CO_2 and O_2 levels in your lungs different when you hold your breath (compared to normal inhaling and exhaling)? Your challenge is to devise an experiment to answer this question. WARNING: PLEASE DO NOT CONDUCT THIS CHALLENGE LONG ENOUGH OR REPEATED ENOUGH TO GET LIGHTHEADED OR PASS OUT.

APPENDIX E

PASCO PRE-TRAINING SURVEY

PASCO Pre-Training Survey

Participation in this survey is voluntary and will not affect your participation in the training. By completing this survey you acknowledge your informed consent of being involved in this research on probeware integration in the science classroom. Your name is for the facilitator's use only and will **not** be used in any reports, papers, or other communications.

1. My Bachelor's Degree is in ________________________________

   Check any additional degrees you have earned and describe each.

   ☐ Teaching Credential ☐ Masters Degree in _________________

   ☐ PhD in ___________________ ☐ other____________________________

2. How many years have you taught? _________________

3. List any previous science-based careers you have had and how long you were at each?

   Science-based career No. of Years

   ____

   ____

4. What subjects are you teaching this year? Select all that apply.

   ☐ Biology ☐ Chemistry ☐ Physics ☐ Earth/Environmental

   ☐ General Science ☐ Physical Science ☐ Life Science ☐ other: ____________

5. What level science courses do you teach? Select all that apply.

   ☐ Advanced/Honors ☐ Regular ☐ Remedial/ Special Education

6. How often do students initiate their own scientific questions and answer them experimentally?

   Rarely Most of the time

   1 2 3 4 5 6 7 8 9 10

   Have you considered changing the amount of this student-directed learning in your classroom? Why or why not?

7. How often do you provide students with the scientific questions and procedures to find answers experimentally?

Rarely — Most of the time

1 2 3 4 5 6 7 8 9 10

Have you considered changing the amount of this teacher-directed instruction with your students? Why or why not?

8. How much technology do you use with your students?

No technology — Lots of technology

1 2 3 4 5 6 7 8 9 10

List the technologies you use:

9. How many years have you used probeware with your students? ___________years

On average, how often do you use **probeware in a month**?

0 1 2 3 4 5 6 7 8 9 10+

Do you want to use probeware more or less often? Explain.

10. What is your comfort level with using SPARK?

Not at all comfortable — Very comfortable

1 2 3 4 5 6 7 8 9 10

If your comfort level is low, how can you improve on it?

11. On average, how many labs or investigations do your students do in a month?

0 1 2 3 4 5 6 7 8 9 10+

Have you considered changing the number of labs you do? Why or why not?

12. How do students learn science content in your class? **If you use more than one method, prioritize your answers by putting a number "1" after the most important description, a "2" after the second most important, etc.**
    - ☐ Students use data collected from experiments (conducted by them or others) to construct their own understanding of the science content.
    - ☐ Students receive explanations of science concepts and then explore these ideas with hands-on activities.
    - ☐ First students are shown a demonstration or discrepant event and discuss it. Then students investigate why it occurred and do more hands-on activities to solidify their ideas.
    - ☐ Students learn most science content from lectures and their textbook.
    - ☐ Students engage in project-based learning activities that involve a mixture of activities, labs, and lectures/discussions.
    - ☐ Other: ____

13. What circumstances best describe why you are attending this training? Select all that apply.
    - ☐ I initiated and organized the training on my own.
    - ☐ I asked my school/district for this training and they organized it for me.
    - ☐ My school/district offered this training to me and I chose to attend.
    - ☐ My school/district is paying me to attend this training.
    - ☐ My school/district is requiring me to attend this training.
    - ☐ Other: ____

14. What instructional changes will you make as a result of this training?

15. What support does your school provide to help you make these instructional changes?

16. Do you have any additional goals or comments about what you want to accomplish during the PASCO SPARK training?

APPENDIX F

PASCO TRAINING EVALUATION

PASCO Training Evaluation

By completing this survey you acknowledge your informed consent of being involved in this research on probeware integration in the science classroom. Your name is for the facilitator's use only and will **not** be used in any reports, papers, or other communication.

Circle the response that most closely reflects your opinion.

SA – Strongly Agree	A – Agree	N – Neutral	D – Disagree	SD - Disagree

Use the comments section to explain your opinions.

1. The training structure was well designed. SA A N D SD
   Explain your choice.

2. The training content was relevant to me. SA A N D SD
   What did you like most about it?

   What did you like least about it?

3. The instructor facilitated the training effectively. SA A N D SD
   What helped you the most?

   What helped you the least?

4. I am ready to use SPARK in my classroom. SA A N D SD
   Explain your choice.

5. I will follow my SPARK action plan. SA A N D SD
   Explain your choice.

Please respond to the following items by checking the appropriate box. Use the comments section to add any explanations or suggestions you have.

	Too short	OK	Too long
6. The length of the training was… Comments:	❑	❑	❑
	Too easy	**OK**	**Too hard**
7. The level of difficulty was… Comments:	❑	❑	❑
	Too little	**OK**	**Too much**
8. The amount of information was… Comments:	❑	❑	❑

9. How comfortable are you with using SPARK?

Not at all comfortable — Very comfortable

1 2 3 4 5 6 7 8 9 10

Explain your choice.

10. What **two** aspects of the training were most helpful to you?

- ☐ SPARK Overview Handout and Discussion
- ☐ Instructor demonstrations and guided lab activities
- ☐ Hands-on approach
- ☐ The SPARK implementation guide
- ☐ Time to plan and practice how you will implement SPARK in your classroom
- ☐ Presenting “mini” lessons to the group
- ☐ Watching my colleagues present
- ☐ Other/Comments:

11. Identify one or two ways to improve the effectiveness of the training.

12. What support will you need after this training to help you use SPARK in your classroom?

13. Please add any additional comments or feedback below:

APPENDIX G

PASCO POST-TRAINING SURVEY

PASCO Post-Training Survey

By completing this survey you acknowledge your informed consent of being involved in this research on probeware integration in the science classroom. Your name is for the facilitator's use only and will **not** be used in any reports, papers, or other communication.

1. How effective was the PASCO training on helping you use SPARK your classroom?
   Not at all helpful Very helpful
   1 2 3 4 5 6 7 8 9 10
   Explain your rating.

2. How comfortable are you with using SPARK?
   Not at all comfortable Very comfortable
   1 2 3 4 5 6 7 8 9 10
   Explain your rating.

3. How many times have you used SPARK with your students since the PASCO training?
   0 1 2 3 4 5 6 7 8 9 10+
   In what ways have you used it?

   What were students' reactions to using SPARK?

4. How do you use the SPARK in your classroom? Check all that apply.
   - ☐ I haven't used SPARK yet.
   - ☐ I project SPARK software for the entire class to see.
   - ☐ I use SPARK during lectures to do classroom demonstrations.
   - ☐ Students collect data in small groups during class discussions.
   - ☐ Students perform SPARKlabs that came on the SPARK (OPEN).
   - ☐ Students perform PASCO paper labs by Building their own displays to collect data.
   - ☐ Students perform SPARKlabs that I created on my own.
   - ☐ Students perform paper labs that I have customized to be used with probeware.
   - ☐ Other/Comments:

5. How do your students submit the data collected on SPARK to you? Check all that apply.

   - ☐ I haven't had the students turn in any data they collected on SPARK.
   - ☐ Answers are written on a separate piece of paper or in a lab notebook.
   - ☐ Answers are captured using the snapshot button and stored in SPARK's digital journal. The digital journal is then turned in and I view it electronically.
   - ☐ Answers are captured using the snapshot button and stored in SPARK's digital journal. The journal is then printed and the printouts are turned in.
   - ☐ Students enter their answers and then save the entire SPARK file. I use SPARKvue to look at their labs.
   - ☐ Students export their data to Excel, Google Docs, or another program and then turn in the information in the new format.
   - ☐ Other/Comments:

6. How closely did you follow your SPARK action plan?
   - ☐ I followed it exactly and did everything I had planned.
   - ☐ I completed about a third of my plan.
   - ☐ I completed about two-thirds of my plan.
   - ☐ I used SPARK, but not in the way I planned.
   - ☐ I have not started the plan yet, but I hope to soon.
   - ☐ I have not used SPARK and do not intend on using it any time within the next month.

   Explain any deviations you made:

	Yes	**No**
7. Did you ever contact PASCO's Teacher Support for help? If yes, explain:	☐	☐
8. Did you use any resources available on PASCO's website for help? If yes, explain:	☐	☐
9. Did you receive any support from people at your school or in your district? If yes, describe the support:	☐	☐

10. What barriers (if any) have you found for the implementation of SPARK? Check all that apply:

    - ☐ I forgot how to use SPARK.
    - ☐ I am not confident using SPARK.
    - ☐ I am not sure how to incorporate SPARK into my current curriculum.
    - ☐ I am concerned about troubleshooting problems.
    - ☐ I don’t think probeware is a valuable tool for my students.
    - ☐ I don’t have access to probeware when I need it (my colleagues are using it)
    - ☐ I am afraid the students will break or misuse the equipment.
    - ☐ I prefer the labs and activities I already use.
    - ☐ I lack other supplies like consumables or glassware that I need to do the labs I want to try.
    - ☐ I have not found any barriers to using SPARK.
    - ☐ Other (please specify): ____

11. Select the aspect of the training that you found most helpful.

    - ☐ SPARK Overview Handout and Discussion
    - ☐ Instructor demonstrations
    - ☐ Guided lab activities
    - ☐ The SPARK action plan and implementation guide
    - ☐ Presenting to the group
    - ☐ Watching my colleagues present
    - ☐ Other/Comments:

12. What would you have liked to experience in the PASCO training that could improve your implementation of SPARK in your classroom?

13. What school or district support has helped with the implementation of SPARK in your classroom? What support do you still need?

14. What benefits have you found from using SPARK in your classroom?

APPENDIX H

INTERVIEW QUESTIONS FOR TEACHERS

Interview Questions for Teachers

Questions were customized for each teacher using the data instruments already collected. Permission to record the interview was requested prior to the interview.

1. Describe your teaching style.
    a) What percent of class time is spent on labs? Why do you feel that is a good percentage?
    b) How much inquiry do you use? (student directed learning)
    c) Would you like to change the amount of inquiry you use with your students? Why or why not?
    d) Do you use textbooks? How? How often?

2. Describe your experience with SPARK over the last 6 weeks.
    a) What obstacles did you face? How could you improve this situation?
    b) What successes did you have? Why was it a success?

3. Did the PASCO training help you implement SPARK?
    a) What aspects of the training were helpful? Why?
    b) What would you like to see done differently?

4. How did you use your SPARK action plan?
    a) Did you look at the SPARK action plan?
    b) What did you follow through with in the plan?
    c) What did you not do? Why not? What would help you do this?
    d) What are your implementation plans for the next two weeks?

5. After the SPARK training did your comfort using SPARK in the classroom change? In what way and to what degree?
    a) What features on SPARK are you most confident with?
    b) What features do you want to practice more? What might be a good way to practice this?
    c) What features do you want to learn? How will you learn these features?
    d) How comfortable are your students with SPARK lessons? How did they catch on? Do you feel comfortable learning from them?

6. Is SPARK a valuable tool for teaching science? Why or why not?
    a) How does it help your students learn? What could be done to make it better?
    b) What new challenges does it introduce? How can you overcome these challenges?

7. What support have you received from your school/district?
    a) Does your school/district encourage you to use SPARK? How?
    b) Have you supported other teachers in your school?
    c) Do you have a network of support you can use to discuss the challenges and successes you face when using SPARK? Describe how the network works.
    d) Are there any plans for future trainings?

8. Is there anything else that might be helpful for me as a trainer to know?

APPENDIX I

INTERVIEW QUESTIONS FOR SCIENCE COORDINATORS

Interview Questions for Science Coordinators

Questions were customized for each science coordinator using the data instruments already collected. Permission to record the interview was requested prior to the interview.

Background

1. Can you describe your background and how you ended up in your current position?
2. Describe your role in the school/district.
    a. What is your involvement with SPARK?
    b. Since the PASCO training, how much contact have you had with the teachers who attended the training? In what ways? Can you give me some specific examples?

3. How did the SPARK training fit into the bigger professional development plan of science teachers in the school/district? Can you give me some examples?
    a. What other new skills/concepts are the teachers working on?
    b. What role do the teachers have in selecting their professional development?
    c. Was SPARK specifically requested by the teachers?

4. What goals does the school/district have for SPARK? Why was the investment made?
    a. What behavioral changes are you looking for?
    b. What data is being used to determine whether the goals have been met?

SPARK Implementation & PASCO Training

5. How do you feel with the usage of SPARK so far?
    a. Has SPARK been used more or less than you expected?
    b. Are your teachers comfortable using SPARK? Can you give me some examples?
    c. Have you seen the instructional changes you were expecting? Why or why not?

6. Have your teachers followed their SPARK action plans?
    a. How do you know?
    b. How has SPARK been used?
    c. Why haven't some teachers used SPARK?
    d. Was this a valuable activity?

7. How effective was the PASCO training?
    a. What worked well?
    b. What changes could be made to better help teacher implement SPARK?

8. Do you or your teachers find SPARK to be a valuable tool? Why or why not?
    a. What successes have you observed?
    b. What new challenges does it introduce?

<u>Comfort with SPARK</u>

9. Did your comfort in using SPARK change as a result of the SPARK training?
    a. Are you comfortable enough to train new teachers? Why or why not?
    b. Are you comfortable enough to succeed in your role?
    c. Did your comfort increase as a result of the PASCO training?

10. How comfortable are your teachers using SPARK?
    a. Did their comfort level change as a result of the SPARK training?
    b. Are they comfortable enough to use it in their classes?
    c. What will be done with the teachers who are not comfortable?

<u>Trends in SPARK Use</u>

11. Have you noticed any patterns in the type of teacher using SPARK?
    a. Do years of teaching experience influence the usage of SPARK?
    b. Is SPARK used more in certain subjects or levels?
    c. How does teaching philosophy affect SPARK usage?

<u>Support for Teachers</u>

12. What support has the school/district provided since the SPARK training?
    a. Have you personally supported any teachers? How?
    b. Do the teachers have a network of support that they can use to discuss the challenges and successes they face when using SPARK?

13. Are there any future plans for long term support with implementing SPARK? Can you give me an example?
    a. Will there be designated school/district experts that teachers can turn to for support?
    b. Are you planning on additional trainings?
    c. What would you see as the “next steps” for your teachers?

14. Is there anything else that might be helpful for me as a training to know?

APPENDIX J

Revised Workshop Agenda

Revised PASCO Workshop Agenda

Changes in PASCO Workshop Agenda are italicized.

Session (90 min)	**PASCO Workshop - Implementation Emphasis**	**PASCO Workshop – Revised Based on Action Research**
Before		*Pre-survey*
1	Introductions, Pre-survey, & SPARK Overview (30 min)	Introductions, demonstration, SPARK *overview with small class discussion* (30 min)
	Periodic Sampling w/SPARKlab (30 min)	Periodic Sampling w/SPARKlab *writing answers on paper* (20 min)
	Data Analysis, conclusions, and a discussion on how to implement SPARK in the classroom (30 min)	Data Analysis, conclusions, and a discussion on how to implement SPARK in the classroom *including barriers teachers face*. (40 min)
Break		
2	Perform a paper Lab using the Build Path (45 min)	Perform a paper Lab using the Build Path (40 min)
	Presentation of labs (30 min)	Presentation of labs (30 min)
	SPARK Action Plan (15 min)	SPARK Action Plan (15 min)
		Mid-training survey (5 min)
Lunch		
3	PASCO implementation planning (15 min)	PASCO implementation planning (15 min)
	Perform a lab of your choice. (45 min)	*Differentiated Session:* (45 min) Perform a lab of your choice a- *using methods already learned* b- *do the lab electronically and learn to manage files.*
	Presentation of your lab including the sensor you used and SPARK features (30 min)	Presentation of your lab including the sensor you used and SPARK features. *Show live data collection during your presentation*. (30 min)
Break		
4	Practice a challenge activity, demonstration, or group discussion activity (30 min)	Practice a challenge activity, demonstration, or group discussion activity, *or learn an advanced topic*. (30 min)
	Present the activities (20 min)	Present the activities (20 min)
	Finalize SPARK action plans (20 min)	Finalize SPARK action plans (20 min)
	PASCO resources and Workshop Evaluation (20 min)	

APPENDIX K

Revised SPARK Action Plan

Revised SPARK Action Plan
How will you use SPARK in the next six weeks?

In which class will you implement SPARK? ___________________________________

SPARK Activity #1: ___________________________ Standard/Unit: _____

Which of the following best describes your activity?

☐ Demonstration ☐ Small group during class discussion ☐ Student lab

Will student work be collected? ☐ Yes ☐ No
If yes, how? ☐ Paper ☐ Electronically

What barriers may make this difficult and how will you overcome them?

SPARK Activity #2: ___________________________ Standard/Unit: _____

Which of the following best describes your activity?

☐ Demonstration ☐ Small group during class discussion ☐ Student lab

Will student work be collected? ☐ Yes ☐ No
If yes, how? ☐ Paper ☐ Electronically

What barriers may make this difficult and how will you overcome them?

SPARK Activity #3: ___________________________ Standard/Unit: _____

Which of the following best describes your activity?

☐ Demonstration ☐ Small group during class discussion ☐ Student lab

Will student work be collected? ☐ Yes ☐ No
If yes, how? ☐ Paper ☐ Electronically

What barriers may make this difficult and how will you overcome them?

What activities would you like to do, but they do not fit into the curriculum in the next six weeks? List the activities here:

Activity	Time Frame

APPENDIX L

IRB EXEMPTION LETTER

MONTANA
STATE UNIVERSITY

INSTITUTIONAL REVIEW BOARD

For the Protection of Human Subjects
FWA 00000165

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MEMORANDUM

TO: Amy Flindt

FROM: Mark Quinn, Ph.D. Chair *Mark Quinn CJ*
Institutional Review Board for the Protection of Human Subjects

DATE: May 9, 2011

SUBJECT: *Probeware Integration in the Science Classroom: The Impact of a One-Day Professional Development Training that Combines Technical Instruction with Implementation Planning [AF062011-EX]*

The above research, described in your submission of June 20, 2011, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal Regulations, Part 46, section 101. The specific paragraph which applies to your research is:

___ (b)(1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

_X_ (b)(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

___ (b)(3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

___ (b)(4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

___ (b)(5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

___ (b)(6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.