Computer Simulation Professional Development: Program Elements That Make a Difference

Amanda L. Gonczi, University of Virginia
Jennifer L. Maeng, University of Virginia
Randy L. Bell, Oregon State University
Brooke A. Whitworth, University of Virginia

Abstract

This study sought to identify professional development implementation variables that may influence the extent and quality of instructional computer simulation use during science instruction. Two participant cohorts in a state-wide professional development program received different computer simulation professional development. Cohort 1 included 52 elementary and 11 secondary teachers and received technically focused computer simulation professional development. Cohort 2 included 98 elementary and 49 secondary teachers. The second cohort's computer simulation professional development provided 3 additional elements thought to influence instructional computer simulation use: (a) modeling desired computer simulation use within an inquiry-based lesson, (b) provision of content-relevant lesson planning time; and (c) modeling desirable instructional support methods. Quantitative and qualitative methods analyzed participants' surveys responses, interviews, classroom observation reports, and classroom instruction while using simulations. A similar percent of cohort 1 and 2 participants used computer simulations during science instruction. In addition, computer simulation use to support nature of science, problem based learning, and inquiry instruction were similar for both cohorts. However, the overall quality of computer simulation implementation was greater in cohort 2 as evidenced by greater external instructional support. These findings have implications for the design and implementation of computer simulation professional development. Technology-related professional development elements commonly expected to increase classroom transfer may be ineffectual in certain educational contexts that limit instructional technology availability.

The pressure for teachers to enact a science curriculum that facilitates student achievement in science and potential future success in a broad range of careers that utilize professionals' ability to apply science content and engage in scientific practices is increasing (National Research Council (NRC), 2012). Student achievement on standardized test scores in America has been declining for at least three decades (Mullis, Martin, Gonzalez, & Chrostowski, 2004). In addition fewer American students are pursuing advanced degrees in science and scientific careers (Tietelbaum, 2004). There are many reasons for these patterns, however a failure in K-12 science education to adequately prepare students to enter and be globally competitive in scientific fields is commonly recognized (Tietelbaum, 2004). Mandated standardized testing contributes to this failure because it creates pressure for teachers to focus on science content rather than on engaging students in scientific inquiry that might utilize scientifically relevant technology (Anderson, 2002). However, as standardized testing has become more important in the American education system, students are not learning the scientific and technological skills needed to pursue engineering and science careers (Tietelbaum, 2004). As a result, science educators are increasingly being encouraged to help students understand and become familiar with actual scientific behavior (NRC, 2012). Technology is utilized in scientific work daily to collect and analyze data. Therefore, increased instructional technology use to support students as they engage in scientific inquiry is also a focus for improving K-12 science education.

Although scientifically relevant instructional technology incorporation is increasingly expected to be a component of science curriculums, many teachers do not readily adopt new technologies (Higgins & Spitulinik, 2008; Zhoa & Bryant, 2006). Teachers may be resistant to instructional technology use because of a lack of comfort with the technology (Russell & Bradley, 1997), a perceived conflict between available time and instructional technology integration (Jimoyiannis, 2010; Pennell & Ewing-Taylor, 2012), or because the teachers do not believe the instructional technology will augment their curriculum (Higgins & Spitulinik, 2008). As a result, there is an emphasis on providing teachers instructional technology professional development that increases science teachers' familiarity with emerging technologies and their importance in science education (President's Council of Advisors on Science and Technology, 2010).

A broad, generalized body of literature outlines effective professional development components that helps teachers adopt and integrate new instructional strategies (Capps, Crawford, & Constas, 2012; Luft, Hewson, & Ntemngwa, 2013). However, the number of studies examining instructional technology professional development is more scant (Lawless & Pellegrino, 2007). Additionally, instructional technology professional development research rarely examines outcomes following participant introduction to a single instructional tool. For instance, Pennell and Ewing-Taylor (2012) investigated teachers' willingness to use instructional technology tools including geopositioning satellite devices and probeware to support students in scientific inquiry following professional development. In another study, Jimoyiannis (2010) reported on studies participants' confidence integrating instructional technology including poweropoint presentations, computer simulations, and probeware following professional development that introduced participants to a wide range of instructional technology. In these studies, research-based conclusions regarding instructional technology professional development effectiveness are generalized without considering differences between different instructional technology types. This is problematic because some instructional technology may present teachers with unique classroom management or integration issues (Guzey & Roehrig, 2009). Therefore, science teachers may adopt some instructional technology tools more readily than others.

An additional deficit in the majority of instructional technology professional development is that conclusions are made about the effectiveness of an implemented professional development program based on changes in teacher practices without a control group and without isolating individual professional development variables (Lawless & Pellegrino, 2007). In the absence of a control group to make comparisons with, researchers can only conjecture that any changes in teachers practices following the professional development was indeed a result of the professional development. Furthermore, many professional development programs are extensively planned and executed with many layers of support (Guzey & Roehrig, 2009; Varma, Husic, & Linn, 2008). Therefore, it is difficult to determine which professional development components may actually have contributed to observed changes in teachers' instructional technology use (Lawless & Pellegrino, 2007). In order to isolate professional development elements that contribute to effective instructional technology integration, changes in participants' classroom practices following professional development programs that vary in key professional development components are needed (Lawless & Pellegrino, 2007).

Computer simulations are one instructional technology tool teachers can use during science instruction. Evidence supporting the educational benefits of instructional science computer simulations is growing (Bell & Trundle, 2008; Dega, Kriek, & Mogese, 2013; Liao & Chen, 2007; NRC, 2011; Plass et al., 2012; Smetana & Bell, 2011; Trundle & Bell, 2010). As a result, a growing number of organizations encourage teachers to incorporate computer simulations into science instruction. However, it is also clear that computer simulations themselves do not ensure positive student outcomes (Marshall & Young, 2006; Steinberg, 2000). Computer simulations need to be integrated within an inquiry-based science curriculum for maximum student achievement and interest in science (Chang & Linn, 2013; Walker et al., 2012). Additionally, computer simulations can be overwhelmingly complex (de Jong & van Joolingen, 1998), include deceptively simple visualizations (Chiu & Linn, 2012), and students' habitual technology use patterns may be counterproductive during computer simulation use (Wecker, Kohnle, & Fischer, 2007). Therefore, science teachers need to be prepared to adequately support students during computer simulation use so that their instructional benefits can be fully realized (Guzey & Roehrig, 2009; Trotter & Zehr, 1999). Given the many potential computer simulation advantages and difficulties to instructional implementation, professional development designed to help teachers use computer simulations, independent of other instructional technology, needs to be examined. Professional development variables that increase participants' instructional computer simulation use as well as participants' quality of implementation need to be clarified.

Computer Simulations

Science computer simulations are models of scientific phenomena and incorporate dynamic visualizations to demonstrate processes that are difficult to observe in the real world (NRC, 2011). Astronomers, physicist, chemists, and biologists regularly use computer simulations for working models and as a means for data collection (Medina & Mauk, 2000; Nada & Furakawa, 2012). Therefore, when teachers incorporate computer simulations into science instruction they provide students opportunities to work like scientists. In addition, students can use computer simulations to observe microscopic and macroscopic phenomena critical to student understanding of these concepts and achievement in science (Liao & Chen, 2007; Plass et al., 2012; Pyatt & Sims, 2012; Ryoo & Linn, 2012; Sun, Lin, & Yu, 2008). For example, computer simulations allow students to observe molecular movement at various temperatures (Chang & Linn, 2013), energy transfer during photosynthesis (Ryoo & Linn, 2012), moon phases and planetary motion (Bell & Trundle 2008; Trundle & Bell 2010), and electric current flow (Finkelstein et al., 2005; Zacharia, 2007).

In addition to improving students' content understanding in Physics (Finkelstein et al., 2005; Ronen & Eliahu, 2000; Zacharia & Anderson, 2003; Zacharia, 2007), Chemistry (Chang & Linn, 2013; Plass et al., 2012; Pyatt & Sims, 2012), engineering design (Klahr, Triona, & Williams, 2007), Life science (Kinzie, Strauss, & Foss, 1993; Rivers & Vockell, 1987), and Earth Science (Bell & Trundle, 2008, Trundle & Bell, 2010), computer simulations may increase students' scientific literacy and proficiency in scientific practices (Huppert, Lomask, & Lazarowitz, 2002; Saab, van Joolingen , & van Hout-Wolters, 2005). For example, Saab et al., examined 21 pairs of 10th grade physics students electronic communication patterns while the students used a computer simulation on individual computers. The researchers noted student pairs debated experimental design methods and data interpretation during simulation use. In addition to significant achievement gains in the students' physics conceptual understanding, the simulation fostered scientific argumentation. In another study conducted by Mäeots, Pedaste &, Sarapuu (2008), the scientific skills of 302 sixth grade Estonian students were measured before and after using 3 plant related computer simulations. Following computer simulation use, the students showed improvement on 7 skills valuable during scientific investigations; problem identification, research question formulation, hypothesis formulation, experiment design, conducting an experiment, data analysis, and conclusion generation. From these and other studies, it is clear computer simulations can help students understand science content and improve their scientific behavior.

Many authors and texts assert computer simulations may help overcome inquiry instruction barriers and increase student engagement in scientific practices (Windschitl, 2000; Kubicek, 2005; NRC, 2011). In some instances, computer simulations may be more affordable or safer than hands on equipment and therefore easier to implement (Ma & Nickerson, 2006). In addition, computer simulations simplify and constrain the learning environment. By eliminating hands on materials and limiting the number of manipulatable variables, students can more easily develop and test their own hypotheses and stay on task when using computer simulations (Finkelstein et al., 2005; Pyatt & Sims, 2012). Finally, students can collect reliable data and conduct more trials in a given time (Klahr, Triona & Williams, 2007). As a result, more classroom time can be devoted to student engagement in argumentation, communication and other scientific practices (NRC, 2011; NRC, 2012).

Science computer simulation research demonstrates positive student outcomes most often when computer simulations are incorporated with external instructional support and are used to engage students in scientific inquiry (Chang & Linn, 2012; Dega, Kriek, & Mogese, 2013; Njoo & de Jong, 1993; Trundle & Bell, 2010; Walker et al., 2012). For example, Trundle and Bell partly attributed greater gains in treatment participants' moon phase conceptual understanding following computer simulation use to the externally supplied instructional support and inquiry-based implementation context. Prior to individual use, the implementers introduced the *Starry Night*™ simulation to the early childhood preservice teachers in the study to increase participant familiarity with the user interface and demonstrate data collection methods. Participants were then able to make predictions and critically engage with the simulation to collect data and test hypotheses related to moon phases. As a result of the external instructional support provisions, participants in the computer simulation group may have been able to use the computer simulation to make greater gains in conceptual understanding compared with the control group that did not use the simulation.

In a more recent study, Dega et al., (2013) compared participants' electricity and magnetism conceptual change following computer simulation use in two conditions. Control group participants made predictions prior to simulation use. The predictions were intended to promote cognitive conflict and conceptual change. The treatment group received external instructional support from the instructor in the form of probing questions intended to extend participants critical engagement with the computer simulation and conceptual understanding. Participants that received the additional instructional support made greater gains in conceptual understanding than control participants. Many externally provided instructional support methods increase computer simulation effectiveness. Accompanying worksheets (Njoo & de Jong, 1993; Rivers & Vockell, 1987), explicit goal provision (Rivers & Vockell, 1987), student/teacher interactions (Dega et al., 2013; Ronen & Eliahu, 2000; Marshall & Young, 2006), whole group simulation instruction prior to individual use (de Jong & van Joolingen, 1998; Bell & Smetana, 2008), and clear instructional goals (Rivers & Vockell, 1987) all help students use computer simulations to achieve instructional goals. These studies bring attention to the many variables, including the instructional context and external instructional support characteristics that may influence student outcomes following computer simulation use.

Although computer simulation research increasingly demonstrates their value in science instruction, not all results have been positive (Baird & Koballa, 1988; Marshall & Young, 2006; Podoloefsy, Perkins, & Adams, 2010; Pyatt & Sims, 2012; Steinberg, 2000). Inconsistent instructional technology intervention outcomes may be attributed to "…aspects of instruction, pedagogy, teacher effectiveness, subject matter, age level, fidelity of technology implementation, and possibly other factors that may represent more powerful influences on effect sizes than the nature of the technology intervention." (Tamim, Bernard, Borokhovski, Abrami, & Schmid 2011, p.17). While computer simulation research continues to identify exactly how instructional variables influence student outcomes, there is general agreement that externally provided, individualized instructional support and computer simulation use within inquiry-based science instruction enhance student achievement and interest in science (de Jong & van Joolingen 1998; Gibson & Chase, 2002; Marshall & Young, 2006; NRC, 2011; Rivers & Vockell, 1987; Songer, Lee, & Kam, 2001; Trundle & Bell, 2010).

Instructional Technology Professional Development

Computer simulation research findings demonstrate diverse benefits, but also bring attention to the many variables science teachers need to be aware of and attentive to for the benefits to be realized. Therefore, instructional computer simulation use in science classrooms is not the only goal. Rather, it is effective computer simulation integration that allows students to critically engage with embedded visualizations to learn science content and engage in scientific inquiry. Because of the complexity of instructional computer simulation use, it is likely science teachers need professional development to integrate these tools optimally.

Instructional technology professional development research has most often focused on participant satisfaction with professional development programs (Ketelhut & Schifter, 2011), teacher efficacy (Graham et al., 2009; Pennell & Ewing-Taylor, 2012; Watson, 2006), technological pedagogical content knowledge measures (Angeli & Valanides, 2009; Agyei & Keengwe, 2012; Graham et al., 2009; Koehler, Mishra, & Yayha, 2007; Shin et al., 2009), participants' technology integration intent (Jimoyiannis, 2010), and integration barriers (Jimoyiannis, 2010; Pennell & Ewing-Taylor, 2012; Varma et al., 2008). Fewer studies have examined teachers' classroom practice following technology professional development (Gerard, Varma, Corliss, & Linn, 2011; Zhoa & Bryant, 2006). Studies that have examined teachers' practices following technology related professional development indicate several factors that may facilitate changes in classroom practice and student achievement (Gerard et al., 2011; Guzey & Roehrig, 2009). Gerard et al. reviewed 43 instructional technology professional development research studies and found science teachers were more likely to implement instructional technology when the professional development extended beyond one year and teachers had opportunities to collaborate. In addition, participants were more likely to use instructional technology for reform-based teaching when they had access to pre-existing inquiry-based lesson plans and materials to work from.

Although the findings of Gerard and colleagues (2011) are helpful, the generalized instructional technology professional development research that informed their conclusions did not take into consideration unique digital technology characteristics that may hinder successful classroom integration of individual technology types. For example, in a cross case study with 4 secondary teachers, study participants reported disparate student engagement when various instructional technology types were integrated into science lessons (Guzey & Roehrig, 2009). In addition, the teachers demonstrated unique preferences for and challenges incorporating certain instructional technologies, especially computer simulations (Guzey & Roehrig, 2009). These findings indicate instructional technology professional development research may need to be more nuanced. Different instructional technology types may warrant unique professional development features to enable successful classroom implementation and student engagement.

Situated Learning Theory

Learning is a process of information transfer often mediated by a social context (Brown, Collins, & Duguid, 1989). In fact, the context not only shapes what is learned, but can either facilitate or hinder learning (Lave & Wenger, 1991). For example, a learning environment that includes individuals with varying skill mastery levels provides less-skilled individuals models to learn from (Lave & Wenger, 1991). In addition, when a learner has opportunities to practice new skills in a realistic context under the supervision of more skilled individuals there is a greater likelihood the learner will attempt and adopt new skills (Lave & Wenger, 1991). Conversely, when a context does not provide opportunities for collaborative learning and individual practice it is unlikely individuals will develop new skills on their own (Lave & Wenger, 1991). Socially mediated learning helps perpetuate cultures and skills as novices learn from masters and ultimately replace the masters (Lave & Wenger, 1991). In summary, learning is a social endeavor fostered by modeling, scaffolding, practice, and a realistic context (Brown, et al., 1989; Lave & Wenger, 1991). The extent these variables exist in a learning environment reflect the degree the context has situated the learning process and facilitate the reproduction of communities with distinct skills (Lave & Wenger, 1991).

Teacher professional development should occur within contexts that promote learning and changes in teachers' practices as described by situated learning theory (Lave & Wenger, 1991). This is especially true for technology-related professional development since many teachers are reticent to use emerging technologies (Russell & Bradley, 1997). Situated learning theory suggests that changes in teachers' practices will be more likely to occur when instructional technology use is modeled, teachers are given multiple opportunities to practice using instructional technology with scaffolded support from professional development implementers, and when the professional development environment reflects an authentic learning environment teachers can relate to and envision themselves in (Lave & Wenger, 1991).

Modeling instructional technology use during preservice science teachers methods courses and inservice teachers professional development program has helped teachers incorporate instructional technology into their own lessons (Maeng, Mulvey, Smetana, & Bell, 2013). Modeling instruction with computer simulations can help teachers not only see how to use computer simulations to help students conceptualize science content, but more importantly, how to use them to engage students in scientific inquiry. Previous instructional technology research indicates teachers have difficulty using instructional technology to engage students in actual scientific behavior. Instead, teachers are more likely to incorporate technology into teacher-centered, content-focused lessons (Graham et al., 2009; Waight & Abd-El-Khalick, 2007). However, when computer simulations were modeled for inquiry-based instruction during preservice science teachers' methods classes, the teachers commonly integrated computer simulations into student-centered lessons during their own student teaching (Bell, Maeng, & Binns, 2013; Maeng et al., 2013). The extent this is also true for inservice teachers is unknown, but it is likely modeling inquiry-based computer simulation use during computer simulation professional development would encourage desirable computer simulation use in more student-centered lessons (Ketelhut & Schifter, 2011; Lave & Wenger 1991; Brown et al., 1989).

Therefore, professional development implementers are model instructors for inservice teachers and need to recognize their power to promote change (Windschitl, 2002).

Practice is another factor influencing skill acquisition and teachers' subsequent instruction following professional development (Lave & Wenger, 1991; Meskill et al., 2002; Morrison, 2013). When new skills are repeated, the skills become easier and require less cognitive focus (Berliner, 1991). A professional development context that provides teachers' opportunities to practice using computer simulations and receive feedback from more experience individuals will help inservice science teachers get increasingly comfortable using the technology (Gerard et al., 2011; Lave & Wenger, 1991).

Practice is desirable because it fosters automaticity and psychological ease which can allow teachers to focus on the process of teaching rather than minutiae (Berliner, 1991; Flyvbjerg, 2001). Increased ease may help accomplish two computer simulation professional development goals; (a) teachers will be more likely to incorporate computer simulations into their own science instruction and (b) may be able to use computer simulations to engage student in inquiry learning since the teacher's cognitive energy does not need to be devoted to technology use. Meskill et al. (2002) found distinct differences between novice and more experienced teachers regarding their instructional technology beliefs and implementation patterns. Teachers with less instructional technology experience attributed student learning to technological tools, used technology as a mechanism for rewarding or punishing students, and emphasized product completion. On the other hand, teachers with more instructional technology experience attributed perceived technology as empowering and facilitating a student-driven learning process. These research findings support situated learning theory and suggest that when teachers become learners during professional development, teachers need opportunities for practice so they can increase their comfort using new tools, reflect, and refine new instructional practices (Lave & Wenger, 1991).

Purpose

Research demonstrates the potential value of instructional computer simulation use for students' conceptual understanding (Finkelstein et al., 2005; Liao & Chen, 2007; Plass et al., 2012; Smetana & Bell, 2011) and engagement in scientific practices (Huppert et al., 2002; Saab et al., 2005; Plass et al., 2012) key to science achievement and literacy (NRC, 1996; NRC, 2012). Therefore, computer simulation professional development should be designed and implemented to maximize science teachers' computer simulation use to foster students' understanding of key concepts and what it means to do science. Previous instructional technology professional development research has looked at instructional technology implementation in general rather than on computer simulations specifically (Gerard et al., 2011; Higgins & Spitulinik, 2008; Lawless & Pellegrino, 2007). This is problematic since different technology types may pose unique challenges to instructional implementation (Guzey & Roehrig, 2009).

Student outcomes following computer simulation use are dependent on instructional use methods, including inquiry-based teaching (Edelson, Gordon, & Pea, 1999; Walker et al., 2012) and external instructional support measures (de Jong & van Joolingen, 1998; Marshall & Young, 2006; Rivers & Vockell, 1987; Ronen & Eliahu 2000). A teacher's role may be even more critical to student learning outcomes when computer simulations are utilized than in lessons utilizing other instructional technology (Grant & Hill, 2006; Trotter & Zehr, 1999). An enhanced instructional role during lessons incorporating computer simulations may be necessary to help students learn collaborative and communication skills (Grant & Hill, 2006), prevent students from “mindlessly” clicking through a simulation (Wecker et al., 2007), and help students critically examine visualizations (Chiu & Linn, 2012). As a result, computer simulation professional development needs to not only familiarize teachers with the instructional tools, but also prepare them to implement them effectively to overcome students’ habitual technology use patterns and facilitate critical engagement (Chiu, Chen & Linn, 2013; Lawless & Pellegrino, 2007; NRC, 2011; Trotter & Zehr, 1999; Wecker et al., 2007). Therefore, research is warranted to identify professional development elements that not only increase the number of teachers who incorporate simulations into science instruction but also improve the quality of computer simulation implementation. A computer simulation professional development program that situates learning more extensively is likely to promote more desirable changes in participants’ extent and quality of computer simulation use. Therefore, to determine whether modeling and practice opportunities during computer simulation professional development may actually increase participants extent and quality of instruction computer simulation use different computer simulation professional development needs to be implemented and outcomes compared.

The following questions guided the investigation to compare participant computer simulation use following two computer simulation professional development programs. In one professional development program, situated learning theory was not considered during design and implementation (technical professional development). In the second professional development program, implementers modeled desirable computer simulation use within an authentic inquiry context and provided opportunities for participants to practice using computer simulations and designing lessons with computer simulations (situated professional development). It was hypothesized a greater percentage of participants in the situated professional development would use computer simulations during their science instruction. In addition, as a result of implementer modeling, a greater percent of participants from the situated professional development would use computer simulations within scientific inquiry contexts and provide students instructional support.

1. How and to what extent did participants in each computer simulation professional development program implement computer simulations into their science instruction?
2. What contextual factors influenced instructional computer simulation implementation?

Methods

Context

The participants in this study were part of a broader state-wide science professional development program. *Virginia Initiative for Science Teaching and Achievement* (VISTA) helps elementary and secondary science teachers understand methods of student-centered teaching including problem-based learning (PBL), hands-on science (HOS), and inquiry instruction. In addition, VISTA focuses on teachers’ nature of science (NOS) understanding and encourages explicit nature of science instruction with science students. VISTA defines these constructs as (Mannarino, Logerwell, Reid, & Edmondson, 2012):

- <u>Problem-based learning</u>: Students solve a problem with multiple solutions, over time, like a scientist in a real-world context; both the problem and context must be meaningful to students;
- <u>Inquiry</u>: (1) Asking questions; (2) collecting and analyzing data; (3) using evidence to solve problems;

- <u>Nature of science instruction</u>: the values and assumptions inherent to the development of scientific knowledge. Key elements include: (1) scientific knowledge is empirical, reliable and tentative, and based on observation and inference, (2) scientific theories and laws are different kinds of scientific knowledge, (3) scientists use a variety of methods to develop scientific knowledge;
- <u>Hands on science</u>: Students using real science materials when safe and appropriate in ways similar to a scientist.

In addition to promoting the inclusion of NOS, PBL, HOS, and inquiry, VISTA encouraged instructional technology use. In particular, VISTA encouraged technology use within these constructs and to support students' technological and scientific literacy (International Society for Technology in Education (ISTE), 2008; NRC, 1996; NRC, 2012). To help address technology integration VISTA participants received computer simulation professional development. In addition, ExploreLearning® (EL) provided participants accounts that gave access to their commercial simulations and supporting instructional materials.

Participants

Participants were all elementary and secondary VISTA participants during two consecutive years. Cohort 1 participants included 52 elementary and 11 secondary teachers. Cohort 2 participants included 98 elementary and 42 secondary science teachers. Each cohort participated in VISTA for 1 year.

Elementary treatment teachers participated in the VISTA Elementary Science Institute (ESI) as teams of 2 to 5 teachers from a common school and taught science to fourth, fifth or sixth grade students. VISTA elementary participants had prior teaching experience that spanned 0 to 38 years and averaged 9.8 years. Secondary teachers participated in the VISTA Secondary Teacher Program (STP). Teachers in the STP were uncertified, provisionally-licensed, or licensed first or second-year secondary science teachers who taught grades 7-12 science (i.e. life science, physical science, environmental science, earth science, chemistry, physics).

Treatment

Cohort 1 participants received computer simulation professional development that lasted approximately 2.5 hours and occurred in one session. During the computer simulation professional development, implementers introduced participants to computer simulations and aspects of technical use (*technical professional development*). In addition, implementers gave VISTA participants time to browse available computer simulations and consider how they could be incorporated into their own instruction.

Cohort 2 participants received a similar computer simulation overview as cohort 1 participants. However, professional development implementers spent less time on technical use and gave participants less time to browse available simulations. Instead, implementers modeled inquiry instruction using a computer simulation, incorporated content-relevant lesson planning time, and opportunities for participants to show peers their planned lesson (*situated professional development*). During the modeled inquiry lesson, participants worked in groups to develop and test a hypothesis using a computer simulation. Following data collection and analysis, participants shared their conclusions with the whole group. Implementers also modeled and explicitly mentioned desirable instructional support. The implementers went over computer simulation screen face elements and provided a clear instructional goal prior to participant computer simulation use. During participant computer simulation use, implementers walked around the room and asked questions about the experiments and data patterns. Finally, implementers allowed participants to work collaboratively as they made lesson plans and identified potentially valuable simulations to incorporate into their science instruction. The computer simulation professional development for cohort 2 lasted approximately 3 hours and occurred on a single day.

Data Collection

Data sources included professional development observations, ExploreLearning® account log in reports, perceptions surveys, participant interviews, classroom observations, and VISTA observation reports. Experts in qualitative and science education research fields reviewed the interview protocol to establish validity. The variety in data sources helped triangulate and establish reliability in findings.

Professional development observations. The computer simulation professional development was observed to capture professional development implementation and participant experiences. During these observations, evidence of effective professional development elements, implied by situated learning theory, including content specificity, instructional support, participant relevancy, simulation modeling within desired reform-based practices, and opportunities for lesson planning was of particular interest. In addition, participant interactions with peers, implementers and simulations were documented. These computer simulation observations were valuable to help interpret participant instructional simulation use and interview responses about their computer simulation professional development experience. For example, participant disengagement during the computer simulation professional development may predict subsequent participant simulation use. Similarly, modeled instructional simulation use strategies may transfer into participants own classroom practices.

ExploreLearning® login reports. These weekly reports provided the last date VISTA participants logged into their ExploreLearning® account and were used in addition to VISTA observation reports to identify participants for interviews.

End-of-year perceptions surveys. Participants completed end-of-year Perception Surveys electronically at the end of the academic year. In addition to general questions regarding their implementation of VISTA constructs, these surveys asked participants to identify whether they had incorporated computer simulations into science instruction and any contextual factors that limited or prevented instructional computer simulation use.

Interviews (Appendix A). Twelve teachers (8 secondary, 4 elementary) were interviewed to explicate their response to the computer simulation professional development and instructional computer simulation use. Interview questions were designed to gather information about how participants incorporated computer simulations into their science instruction, including instructional support methods. These interviews helped triangulate data in videotaped classroom observations. Participant teachers were chosen for interviews based upon evidence of instructional computer simulation use from weekly ExploreLearning® log in and VISTA observation reports. These semi-structured interviews lasted approximately 30 minutes and were audiotaped and transcribed for analysis.

Classroom observations. VISTA participants were observed and videotaped teaching science four different times during the academic year. Instructional computer simulation implementation was observed in 7 (6 elementary, 1 secondary) lessons the first year and 19 lessons (12 elementary, 7 secondary) the second year. These lessons were qualitatively analyzed to identify patterns in instructional computer simulation use.

VISTA observation reports (Appendix B). Observation reports recorded elements of instruction during an observed class period and three classes prior to and following the observed class to provide context. For each treatment participant, all 4 VISTA observation reports were analyzed for evidence of computer simulation use during science lessons to establish extent of participant computer simulation use.

Data Analysis

Data were analyzed using descriptive statistics and qualitative methods. VISTA observation reports were quantitatively analyzed to determine the percent of participants that used computer simulations throughout both academic years as well as during each of the four observation windows. Field notes were made for all professional development and videotaped classroom observations with simulations and used to complete a descriptive writeup that included pertinent observations and inferences for each observation. Observation writeups were qualitatively and systematically analyzed for computer simulation use within PBL, inquiry, NOS, and HOS instruction. Two additional instructional purpose categories emerged during video data analysis. First, all science lessons had content related instruction goals. Second, students often collected data without an underlying research question that is fundamental to VISTA's scientific inquiry definition. This instructional simulation use was coded as scientific practices (NRC, 2012). Science instruction categories were not mutually exclusive. For example, a lesson could be coded as inquiry and problem based learning.

Instructional support provisions during both computer simulation professional development programs and participants' science lessons were coded (Miles & Huberman, 1984). Relevant computer simulation instructional support categories identified from the literature were initially used to code the observational data. The initial instructional support categories included worksheets (Njoo & de Jong, 1993; Rivers & Vockell, 1987), student/teacher interactions (Dega et al., 2013; Ronen & Eliahu, 2000; Marshall & Young, 2006), whole group simulation instruction prior to individual use (de Jong & van Joolingen, 1998; Bell & Smetana, 2008), and clear instructional goals (Rivers & Vockell, 1987). However, during analysis additional instructional support measures that potentially influenced students were identified. The student/teacher interaction category was refined to reflect individual student-teacher interactions during computer simulation use and whole group teacher-led discussions following student computer simulation use. Additionally, pacing student work was identified as an instructionally supportive teacher action.

Participant open-ended perceptions survey responses and interview transcripts were first read to establish emergent themes relating to teachers instructional context that facilitated or hindered computer simulation use (Erickson, 1986). The open-ended perceptions survey responses were analyzed to identify common computer simulation integration barriers. Barrier categories reflect a common response from at least two participants. Interview transcripts were analyzed to identify themes in participants' experiences during and recommendations for computer simulation professional development. The interview data also helped triangulate findings and themes relating to patterns in participants' science computer simulation use, computer simulation integration barriers, and instructional support techniques. The primary researcher established all code categories and initially coded all data. A second researcher examined a subset of the data, provided feedback on code categories and coded a subset of video data. Instances of code differences were resolved through discussion and systematic examination of code criteria and data.

Results

Extent of Computer Simulation Use

There were virtually no differences in the percent of elementary teachers that utilized computer simulations in cohort 1 and cohort 2. VISTA observation reports documented computer simulation use by 19 of the 52 (36.5%) cohort 1 elementary participants and 35 of the 98 (35.7%) cohort 2 elementary participants (Figure 1). The percentage of secondary cohort 2 treatment participants that used computer simulations was slightly higher than for the first cohort. Two of the eleven (18.2%) cohort 1 secondary participants and 11 of the 42 (26.2%) cohort 2 secondary participants used simulations during science instruction (Figure 1). These patterns might indicate that even though implementers modeled desirable instructional computer simulation use and provided content-relevant lesson planning time during the 2nd cohort's computer simulation professional development, these additional elements were insufficient to yield major changes in the percent of participants that would adopt the new technology.

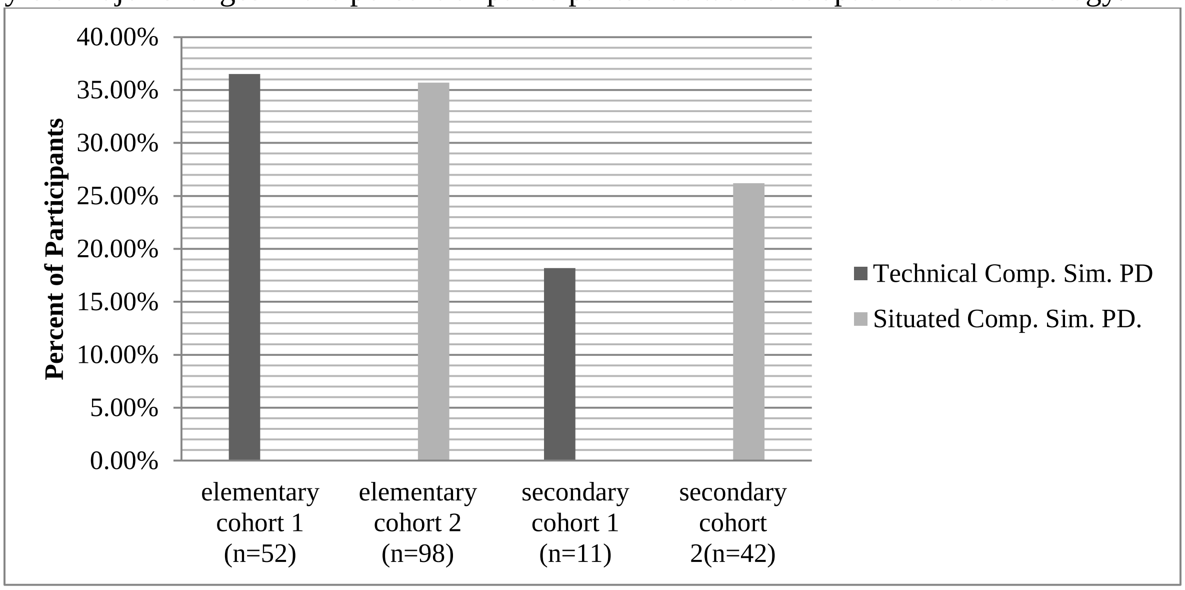

Figure 1. Percent of elementary and secondary cohort 1 and 2 VISTA participants that incorporated computers simulations into their science instruction.

Barriers to Instructional Simulation Use

Participants experienced many barriers that may have limited their computer simulation use and provides an explanation for the similar extent of computer simulation use in cohorts 1 and 2. The primary factor limiting computer simulation use was participant access to computers. Participants explained that computer access in many schools is less than desirable and arranging computer access often required extensive future planning. Additionally, computer-based standardized testing restricted computer access throughout the academic year.

Although computer access and time considerations were the most common factors limiting instructional computer simulation use, additional barriers existed. These barriers included software compatibility issues, slow or absent internet connectivity, limited participant confidence using computer simulations, instructional support challenges, planning time limitations, and lack of age and content appropriate computer simulations. Although several of these barriers emerged in both elementary and secondary perception survey responses, elementary participants seemed to experience a broader range of barriers (Table 1). Names in Table 1 and throughout the remaining results are pseudonyms.

Table 1

Barriers to Instructional Computer Simulation Use (Perceptions Survey Responses)

Barrier	Sample Response	Number of Elementary Participants n=92 (%)	Number of Secondary Participants n=48 (%)
Insufficient Computer Access	…we did not get computers into our classrooms until mid-January. Out of the four computers, two consistently worked and two had issues -no internet connection and would not turn on. (Collette)	51 (55.4%)	28 (58%)
Time Constraints (Instructional or Planning)	I only have 45 minutes every other week to teach science. (Lionel) I had a strong desire to use these programs, just limited time in order to search to find what was available. (Tico)	16 (17.4%)	9 (18.8%)
Software Problems	I did not use the simulations as much this year. One reason was…our student laptops did not have the necessary software on them... (Percy)	7 (7.6%)	8 (16.7%)
Internet Connectivity	The one and only difficulty that I had was not being able to connect to the internet because there were not enough hotspots in the school. (Emma)	6 (6.5%)	4 (8.3%)
Technology Efficacy	I am also not that confident with using the computer so I was not able to use it that much. (Daphne)	6 (6.5%)	0 (0.0%)
Simulations designed for older students	I did not use computer simulations because there were very few lessons applicable to the grade level I taught. Almost all of the simulations were for the upper grades. (Trent)	5 (5.4%)	0 (0.0%)
Simulations did not address content	Some of the topics I teach do not have simulations that align. (Parker)	4 (4.3%)	2 (4.2%)
School Policy/ Administration	I was also told by the assistant principal …that we should be doing reading and math when in the computer lab, not computer simulations for science. (Max)	3 (3.3%)	2 (4.2%)
Instructional Support Difficulties	It is also sometimes frustrating to have students who need such a large degree of assistance at times. (Tico)	3 (3.3%)	5 (10.4%)
Ineffective Professional Development	Honestly, I did not feel that I had adequate training in using the simulations – nor the time to teach it to myself. (Tara)	2 (2.2%)	0 (0.0%)

Note: Percentages are based on the number of perception survey responses

Interview and observational data confirmed participant difficulties implementing instructional computer simulations. For example Dina explained, "…my biggest challenge is having availability on the computer and having shockwave running…and updated" (Interview). Software challenges were apparent in two different observed lessons. In one of these lessons the participant discovered student laptops were not updated with Shockwave that was needed for the simulation to work. Twenty minutes of instructional time was lost as the participant updated student computers (Gabe, 3rd Observation). Students in Celine's Environmental Science class could not get any of the student laptops to run the simulation properly. As a result, Celine proceeded to project the water pollution simulation onto the SmartBoard™ and engage the class in whole group instruction (Celine, 3rd Observation). Later, Celine determined that students needed to use Firefox® as the web browser rather than Internet Explorer for the particular computer simulation. Therefore, Celine instructed students in her next class period to open the simulation with Firefox®. However, even after 27 minutes, all students had not yet accessed the simulation due to a slow Internet connection. Celine experienced different technology related barriers in two consecutive lessons on the same day demonstrating the barriers many teachers experienced as they made efforts to include instructional technology and accomplish instructional goals within a set time period.

State mandated testing was a commonly cited reason for limited computer access. Dina explained "…with SOL testing and SOL retakes, getting the computer is not the easiest thing to do. And it's going to get increasingly more difficult in the next two weeks for the remainder of the school year." The burden of computerized benchmark testing on instructional technology availability was apparent in several observed lessons. For example, Eve told her class,

> We're going to be finishing up our [simulation] lab from yesterday. However because of the benchmark schedule and availability of computers we're going to have to do the [simulation] lab in larger groups and at two stations to finish those up because I couldn't get another set of computers…So today we are going to have a [simulation] station at the SmartBoard™ and classroom computer (7th Observation).

In another example, Tracy intended to have students use a natural selection-related simulation. However, students could not log in to the computers because of password restrictions implemented during state mandated testing times. As a result, Tracy proceeded to lecture the students for the remaining class time (Tracy, 4th Observation).

Outdated classroom computers further limited instructional technology incorporation. In Carolyn's interview she explained the challenge of sharing one computer laptop cart set with six additional team members:

> …the limited resources that we have and availability of computers because of online testing, also limits seven teachers in one grade level trying to use the computers effectively… We have older computers that are in our classroom. But we're, most of us are down to 2 or 3 of them that are actually working and functioning. They are out of warrantee and we are working on budget issues trying to come up with a solution for how to get those computers back in classes.

In summary, a slightly higher percentage of cohort 2 secondary participants used computer simulations than cohort 1 secondary participants. There was virtually no difference in the percent of cohort 1 or 2 elementary participants that utilized computer simulations during their science instruction. Although it would appear the situated professional development did not yield greater instructional computer simulation use, evidence suggests widespread technology integration barriers resulted in contexts that prevented participants' continued practice and learning with computer simulations. Situated learning theory posits that learning is an ongoing, context dependent, socially mediated process. Many of the participant teachers were in instructional contexts that prevented further practice using computer simulations. These results indicate instructional technology professional development design and implementation improvements to incorporate situated learning elements may not yield increased classroom transfer due to instructional contexts preventing further practice and professional growth. In essence, many schools staunch the learning process begun during instructional technology professional development programs.

Purpose/Context of Computer Simulation Use

Classroom observation and interview transcript data were analyzed to characterize the context and purpose of participants' computer simulation use. Implementers in the situated computer simulation professional development program modeled inquiry-based computer simulation instruction and provided participant's content-relevant lesson planning time to encourage and enable participants' inquiry-based computer simulation instruction either within or outside of a broader PBL.

Five cohort 1 participant lessons and 19 cohort 2 participant lessons involved instructional simulation use. The small number of recorded cohort 1 participant lessons including simulations made characterization and comparison with cohort 2 participant video data difficult. However, the data suggests participants in cohorts 1 and 2 used simulations similarly within the various contexts (Table 2).

Table 2

Computer Simulation Use Purpose (Classroom Observations)

Type of instruction	Cohort 1 (Technical PD) (n=5)	Cohort 2 (Situated PD) (n=19)
Content/concepts	5 (100%)	19 (100%)
Inquiry-based	2 (40%)	8 (42.1%)
Explicit Nature of science	2 (40%)	2 (10.5%)
Problem-based	1 (20%)	1 (5.3%)
Scientific practices	3 (60%)	14 (73.7%)

Although it was hypothesized that a greater percentage of cohort 2 participants would utilize computer simulations to support inquiry instruction the data did not support this hypothesis. Instead, a similar percent of participants, based upon classroom observation data, used computer simulations to engage students in data collection to answer a research question or solve a problem. Several cohort 2 participants discussed difficulties using computer simulations for inquiry instruction during interviews. Participants explained they were unable to transfer the desired modeled inquiry-based computer simulation use into classroom practice when the modeled lesson did not pertain to their content area. One participant explained she had difficulty implementing inquiry with computer simulations because during the computer simulation professional development, "They showed us a good example of how to do that, but it was a great example for Physics… I teach Chemistry…. I would have liked to see something at least Chemistry-related" (Geri, Interview). Similarly, Sonya would have liked "…more help on how to use them [computer simulations] for inquiry and how to use them for testing experiments or setting up experiments because I don't really have any idea how to do that."

The situated computer simulation professional development included elements that may have helped some participants use computer simulations, but not necessarily for inquiry instruction. Although there was no evidence of increased computer simulation use for inquiry instruction, the following secondary participant's comment indicates the opportunity to plan a lesson using a simulation helped increase her confidence for instructional use:

> I liked how they gave us the intro to it and then they made us do one on our own. Because if you don't do it on your own then your now going to know how to use it. So I'm happy they made us do one on our own (Claire, Interview).

Claire felt she benefitted from the situated practice embedded in the situated computer simulation profession development program. The opportunity for practice increased her self-efficacy and therefore increased the likelihood of instructional implementation. However, the situated computer simulation professional development program may not have situated all participants in a learning context they could fully relate to and therefore some participants could not easily adopt the modeled inquiry-based instructional strategies. The classroom observation and interview data indicate computer simulation professional development needs to not only model inquiry instruction, but also provide examples within as many content areas as represented by the participant population.

Instructional Support

Qualitative, systematic video data analysis of treatment teachers' lessons with simulations revealed 6 implemented instructional support methods. Instructional support is defined in this study as teacher actions intended to facilitate and encourage students' simulation use and science-related learning. Instructional support methods included: (a) whole-class simulation introduction; (b) explicit goal provision; (c) pacing; (d) worksheet use; (e) individual teacher/student interactions; and (f) whole-class closure/discussion.

The different instructional support methods facilitated student simulation use and science-related learning uniquely and participants often integrated multiple support measures in a single lesson. During whole-class simulation introductions, participants projected simulations students would use on a screen and pointed out relevant screen face elements and sometimes modeled appropriate simulation use. Some participants provided explicit research or content-based goals students should be attentive to during simulation use. In several lessons, participants controlled the pace of student simulation use by providing students only a subset of written directions at one time, instructing students to only complete written directions up to a certain point and/or leading discussions after specific simulation activities. By restricting students' movement through simulation exercises participants tried to encourage thoughtful and unhurried student simulation use. In instances when participants led discussions following simulation activities, participants encouraged students to communicate their findings and assess student learning and understanding of targeted science content that would need to be applied in subsequent simulation activities.

Worksheets were the most widely used instructional support method implemented to guide student simulation use. Teachers chose to interact with students in many ways to support successful simulation use and learning. For example, participants asked probing questions to encourage data analysis, redirected off-task students, and provided positive reinforcement during interactions when students demonstrated effort and understanding. Finally, following student simulation use some participants asked questions during whole class instruction to assess student understanding, provide students opportunities to synthesize and articulate findings, and revisit instructional goals.

Although the sample size of cohort 1 was small and prevented any statistical analysis, simple descriptive statistics demonstrated differences in the amount and type of instructional support cohort 1 and 2 participants provided students during simulation-inclusive science lessons (Table 3). Overall, cohort 2 participants provided more instructional support measures during simulation-inclusive lessons (cohort 1 M= 2.4, cohort 2 M=3.1). Cohort 1 and 2 participants implemented explicit goal provision, pacing, and worksheet use to similar extents. A greater percentage of cohort 2 participants interacted with students during and after simulation use to foster critical engagement. This finding is consistent with expectations based upon the situated computer simulation professional development program characteristics. During the situated computer simulation professional development, implementers interacted with participants during and after simulation use. This interaction element was absent in cohort 1's technical computer simulation professional development. Consistent with situated learning theory, modeling supportive student-teacher interactions may have provided examples of good teaching practices participants were able to relate to and adopt in their own classroom.

Table 3
Implemented Instructional Support During Science Lessons With Computer Simulations

	Instructional Support Method # Participants (%)						
	Intro	Goal	Pacing	Work-sheet	Individual student/ teacher interactions	Closure discussion	Mean # instructional support methods/ lesson (SD)
Cohort 1 (n=5)	3 (60%)	2 (40%)	1 (20%)	4 (80%)	1 (20%)	1 (20%)	2.4 (1.3)
Cohort 2 (n=19)	7 (36.8%)	9 (47.4%)	5 (26.3%)	16 (84.2%)	12 (63.2%)	9 (47.4%)	3.1 (3.9)

A smaller percent of cohort 2 participants introduced students to the simulation than cohort 1 participants. This pattern was unexpected and inconsistent with situated learning theory. In addition to modeling an introduction, the situated computer simulation professional development implementers explicitly told participants to introduce students to screen face elements prior to student simulation use. Student groupings during computer simulation lessons may have influenced this finding. For example, in lessons where a simulation was one of several stations students rotated through, none of the participants provided a whole-class simulation introduction. The potential relationship between computer simulation use methods and instructional support provisions was not specifically examined in this study. However, it is possible the method of simulation implementation influences teacher practices in the classroom and should be investigated with a larger sample size.

The additional instructional support that many cohort 2 participants implemented may have increased student engagement and learning during simulation use. The following classroom example from a second cohort participants' fifth grade class demonstrates exemplary whole group instruction to focus student attention on proper simulation use.

Classroom Observation

Chrissy starts the lesson by having students sit in front of the SmartBoard™. Chrissy tells the students, "You're going to have the opportunity to watch a food web change over time." During the introduction, Chrissy shows students relevant simulation elements such as the "reset" button, demonstrates how to manipulate variables and provides a clear goal for student Gizmo® use. After pointing out the dependent and independent variables, the Chrissy tells the students, "Let's *go ahead and do one of these simulations." The students guide the teacher in setting ecosystem parameters such as a diseased hawk and healthy snake population. As the simulation plays, Chrissy tells the students to "look at how the numbers are changing." The students yell out explanations for what they see such as, "…because the grass is diseased" or, "They're eating it." After students finish making observations Chrissy shows students how to access and interpret the data table and bar graph. The students look at the graph to answer questions such as, "What trend do you see in the hawks? What trend do you see in the rabbits?". The students are told to determine what happens in the ecosystem when there are no hawks. Following this initial investigation students are permitted to develop and test their own research questions. After students are done working independently Chrissy asks the students to reflect on what was the most important lesson learned during simulation use that day. One girl summarizes her thoughts and shares with the class, "Even if the animals have like enemies they all need each other to survive. Like even though the snake and the hawk, they're enemies – they still need each other to survive no matter how much they don't like each other. (Chrissy, 1st Observation)*

Chrissy's simulation introduction permitted students' successful independent simulation use. In addition to introducing relevant screen interface elements, Chrissy also provided students an overall objective and modeled desired simulation use. For example, Chrissy led students through the data collection and analysis process. The introduction familiarized students with the simulation and demonstrated intended use to promote deep student engagement during individual simulation use. The final closure discussion provided Chrissy an opportunity to assess student understanding. In addition, Chrissy's broad closing ecosystem-related question prompted students to develop a deeper, contextualized understanding of their findings and reflect on the simulation's purpose. Without the participant's support and prompting, it is unlikely students would have been able to engage as critically with the simulation and make such broad ecosystem-based conclusions.

Greater instructional support provisions typical in cohort 2 seemed to encourage positive student interactions with and responses to simulations compared with less instructional support typical in cohort 1. A cohort 1 participant's science lesson highlights potential student difficulties when sufficient instructional support is not provided.

Classroom Observation

Students in Kilby's elementary science class are exploring what happens to water molecules when they are cooled and heated using a simulation. The students have been given the instructions to share computers with a classmate while using the simulation. Kilby does not give any other verbal or written instructions. As the students work, one student gets out of his seat and looks at his neighbor's computer screen for guidance. Another male student tells his partner, "I'm confused. You think we should turn it into ice?" Another student says, "What do we do?" With only 5 minutes remaining in the class, none of the students have written anything down. Although Kilby never stopped circulating between groups and provided help, it was all technical help relating to computer use. One student sighs and says, "This is never going to work." A female student walks over to a male classmate who tries to help her, "I think you have to do that first." The girl goes back to her computer to follow his instructions but when she gets back to her desk Kilby announces there is, "One more minute left." The young lady slumps her shoulders and sits down at her computer. (Kilby, 2nd Observation)

The above vignette provides several examples of instances in which students are unclear about instructions. They were not provided a goal, were not introduced to the simulation ahead of time, and did not have a worksheet to guide simulation use. Student confusion and frustration are exemplified in the female student who sought classmate's help and slumped her shoulders when she wouldn't have time to engage successfully with the simulation. Overall the students were interested in the simulation but given the lack of explicit directions by the participant, the students did not know what to do with the simulation. Some students responded positively to the open-ended lesson by developing their own questions, whereas other got frustrated. By not providing clear instructions, the simulation's potential was not realized in the class. There was no evidence of external instructional support in this lesson. In comparison, all participants in cohort 2 implemented one or more instructional support methods. The overall increase in instructional support, and specifically greater student-teacher interactions, typical of 2nd cohort participants, may indicate situating computer simulation professional development within desirable instructional support practices improves classroom computer simulation implementation, student simulation use, and student learning.

In summary, the extent of computer simulation in both participant cohorts was similar. Overall, fewer secondary participants used computer simulations than elementary participants. Participants identified many barriers limiting instructional computer simulation use. Participant computer simulation use to support inquiry-based instruction also yielded similar patterns across cohorts. However, cohort 2 participants instructionally supported students to a greater extent during individual computer simulation use. In particular, cohort 2 participants interacted more extensively with students during and after computer simulation use. Instructional technology barriers and participant recommendations for future computer simulation improvements help explain the similar computer simulation use extent and implementation patterns observed across the 2 cohorts.

Discussion

The situative learning perspective posits learning occurs as a result of participation in social settings with scaffolded opportunities to practice new skills (Lave & Wenger, 1991). Prior instructional technology professional development research indicates the inclusion of content relevant lesson planning time and opportunities to observe desired teaching practices increases classroom transfer consistent with situated learning theory (Gerard et al., 2011; Ketelhut & Schifter, 2011; Pope, Jayroe, Franz, & Hamil, 2008). This study examined how modeling instructional computer simulation use for inquiry instruction with externally provided instructional support and opportunities for practice influenced participants' instructional science computer simulation use. Additional opportunities to participate in a technology-enhanced, science community were expected to lead to more participants using computer simulations, increase instructional computer simulation use to support inquiry instruction, and more instructional support for students during lessons including computer simulations.

Research findings did not support the hypothesis that the situated computer simulation professional development would increase the percent of participants that would utilize instructional computer simulations. Although cohort 2 participants were given more opportunities to become familiar with computer simulations and embed them in their curriculum, technology integration barriers may have negated any of the additional positive professional development elements. Previous instructional technology research has widely noted barriers to technology integration (Gerard et al, 2011; Pennell & Ewing-Taylor, 2012; Zhoa & Bryant, 2006). Although the results of this study coincide with several others indicating technology access is the most common technology integration barrier (Gerard et al., 2011; Pennell & Ewing-Taylor, 2012; Zhoa & Bryant, 2006), limited participant computer access was primarily a result of computerized, state mandated testing procedures (Chandler, 2013) rather than actual lack of physical computers or funding as previously documented (Gerard et al., 2011; Pennell & Ewing-Taylor, 2012; Zhoa & Bryant, 2006). The number of available computers in schools has risen to address research findings and demands for increased instructional technology integration. However, it appears that in many schools computers are being monopolized for standardized test taking procedures.

A social context can foster the development of newly acquired skills as well as provide individuals opportunities to broaden skill repertoires (Lave & Wenger, 1991). The situated computer simulation professional development program occurred within a social context that introduced participants to new skills and gave participants opportunities to improve. However, the instructional context that many teachers subsequently moved into presented widespread technology integration barriers that effectively terminated the learning progress begun in the situated computer simulation professional development program. Learning is an ongoing process that requires repeated opportunities for practice, skill acquisition, and mastery development (Lave & Wenger, 1991).

Situated learning theory explains how communities with unique principles, traditions, and skills perpetuate (Lave & Wenger, 1991). Within any social community there are always individuals with greater skill and knowledge mastery than others (Lave & Wenger, 1991). As long as novices have opportunities to acquire and practice applying new knowledge and skills, communities can continue (Lave & Wenger, 1991). School conditions that prevent or limit instructional computer simulation implementation create educational contexts that potentially prevent skill and knowledge transfer from scientific communities to K-12 science students. Computer simulations provide students opportunities to engage in scientific inquiry (Trundle & Bell, 2010; Winberg & Berg, 2007), master scientific concepts (Dega et al., 2013; Zacharia, 2007), and use technology in scientifically appropriate ways (Medina & Mauk, 2000; Nada & Furakawa, 2012). Without access to computer simulations and other educational technology, science teachers cannot cultivate scientifically and technologically literate students. Therefore the propagation of scientific communities becomes difficult and may partially explain why fewer American students are pursuing science related degrees (Tietelbaum, 2004).

Study participants indicated inquiry-based computer simulation instruction was difficult to achieve despite implementer modeling during the situated professional development. Cohort 2 participants found it difficult to relate the model to their own content. The situative perspective indicates it is essential for learners to be able to relate to teachers for growth (Lave & Wenger, 1991). In this study, the expectation was that modeling inquiry-based computer simulation instruction in any content area was sufficient to achieve a model the participants could relate to. However, the studies findings showed that many of the participants had difficulty implementing computer simulations to support student-centered instruction despite computer simulation affordances that facilitate scientific inquiry (Windschitl, 2000). This study confirms many others in documenting challenges teachers face understanding and implementing inquiry instruction (Anderson, 2002; Grant & Hill, 2006; Windschitl, 2002). Although all participants were introduced to inquiry prior to computer simulations, they still had difficulty integrating the digital tool with the new pedagogy. Participant comments indicated the situated professional development did not fully provide an authentic learning context they could relate to. Therefore, computer simulation professional development needs to be more situated by supporting individual participant's content areas and inquiry knowledge to a greater extent.

All cohort 2 participants implemented instructional support and on average implemented more instructional support types than cohort 1 participants. A greater percentage of second cohort participants interacted with students during and after computer simulation use. During these interactions, participant teachers asked students probing questions, provided content relevant explanations, and helped students use data to develop conclusions. This finding is important because external instructional support is a variable influencing student outcomes following computer simulation and visualization interactions (Chiu & Linn, 2012; de Jong & van Joolingen, 1998; Marshall & Young, 2006; Njoo & de Jong, 1993; Rivers & Vockell, 1987).

The only instructional type that was not provided more often by second cohort participants was an initial computer simulation overview. The context for computer simulation implementation seemed to correspond with participants likelihood of introducing students to screen interface elements and appropriate use. Participants did not introduce students to screen interface elements or desirable use in any science lessons utilizing rotating student centers. Future research should examine the relationship between student groupings, instructional context, and teachers instructional support practices during lessons including computer simulations with a larger sample size. Whole group instruction prior to individual student use is critical to model desirable computer simulation use patterns. Students may have digital technology expectations and use patterns that interfere with deep engagement and science learning (Wecker et al., 2007). To counter student beliefs and habits, teachers need to consistently model and encourage methodical and analytical computer simulation use. Therefore, computer simulation professional development and science instruction variables that encourage teachers to provide students with various instructional support measures should be addressed in future research.

It is promising that intentional attention to and inclusion of situated learning theory and external instructional support elements within computer simulation professional development may improve participants overall quality of computer simulation implementation. External instructional support not only facilitates student computer simulation use, it cultivates a positive learning environment that can increase student achievement and attitudes towards science (Fisher, Henderson, & Fraser, 1997; Fraser, McRobbie, & Giddings, 1993). This study demonstrated, for the first time, that modeling and explicitly discussing instructional support may result in teachers cultivating a positive learning environment marked by student-teacher interactions, class discussions, and positive student experiences with computer simulations. These findings should be replicated with larger sample sizes.

In conclusion, the current study illuminated 3 variables, previously undocumented, that may influence the extent and quality of instructional computer simulations use. First, attention to external instructional support during professional development may result in greater student-teacher interactions that may help students realize computer simulation benefits. Second, teachers may have difficulty incorporating instructional support when students use computer simulations within a rotating student center instructional context. Finally, computerized state-mandated testing procedures impede computer simulation professional development participants from continuing to practice and become more adept at instructional computer simulation use. Well designed and implemented computer simulation professional development may not be able to overcome all technology integration barriers, but may be able to help science teachers cultivate a positive classroom environment and student experiences with computer simulations by incorporating elements that promote external instructional support. Research should continue to explore professional development and classroom variables that influence external instructional support provisions during lessons including computer simulations. In addition, school administrators and policy makers need to consider the broad impacts of computerized state-mandated testing. Science education should provide the next generation with the content knowledge and skills needed to move into and perpetuate science and engineering communities (NRC, 2012). Given schools' current financial and material resources, computer-based achievement testing may limit teacher and student access to instructional technology critical to achieving this goal.

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Appendix A
Interview Protocol (Instructional Computer Simulation Implementation)

Topic 1: Experience and Method of Simulation use by VISTA teachers

1. Tell me about your experiences using simulations.

2. Describe how you incorporate a simulation into a lesson. *Probes: Do you have students use the simulation before introducing the subject matter or afterwards? Do you use handouts or other supplementary materials to guide them through the simulations? If so, where have these supplemental materials come from? Do you use one computer/projector to give whole class instruction or do students work individually or in groups/pairs?*

3. What are some of the simulations you have used? How was this related to the content/skills you were teaching? Describe the content or skills you were trying to teach with these simulations.

4. What are some of the advantages or disadvantages you have found to using simulations? *Probes: In what ways have they affected the content you teach? In what ways have they affected the science skills you teach? Are there any instances in which access to technology has been a challenge?*

Topic 2: Interactions

1. Describe you role when students are using a simulation. *Probes: What sorts of comments might you make to students? How often do you visit a student using a simulation? Describe the amount of and type of support/guidance you give individual students or the class. How is this support similar and/or different to the support you provide during hands on labs? Describe any help students have needed using the screen interface*

2. Describe some of the responses students have had to using simulations. *Probes: describe any evidence you have that students have enjoyed using them. Describe any evidence you have that students have not enjoyed them. Evidence of frustration? Evidence that they are not on task?*

3. How would you characterize the impact of the simulations with regards to helping student learning? Describe any evidence you have that simulations were not successful in helping students learn the intended content/skills. *Probes: Describe comments students made that indicated understanding or lack thereof? Describe instances when students asked classmates for help? How did assessments indicate understanding/or lack of understanding of content/skills?*

Topic 3: Context of Simulation Use

1. If you have used a simulation to support an inquiry-based lesson describe how the simulation was included. Why would you say this was an inquiry-based lesson?

2. If you have used a simulation within a problem-based learning unit, describe the unit and how the simulation was used. Why would you say this was a problem-based unit?

Topic 4: Factors Affecting Simulation Use

1. What are some of the reasons you would use one simulation instead of a different available computer simulation? Why do you choose to use a simulation during science instruction instead of a hands on lab?
2. Describe any factors that would make you more likely to use more simulations in future lessons. *Probes: Describe any recommendations you have for further professional development? How would you like that training to occur (where, duration, content)? Would changes in access to computer technology change your use of computer simulations?*

Appendix B
VISTA Observation Protocol
(Modified from Collaboratives for Excellence in Teacher Preparation Core Evaluation Classroom Observation Protocol [CETP-COP], Lawrenz, Huffman, Appeldoorn, and Sun, 2002)

Section I. Background Information

Observer: **Observation # (bold one):** 1 2 3 4
Teacher Name: **School:**
Grade Level/Content Area:
Date: **Start Time:** **End Time:**
Total number of students in class:

Section II. Contextual Background

Ask teacher before observing:

A. **Objective(s) for lesson:**
B. **How does lesson fit in the current context of instruction? (e.g. connection to previous and other lessons; What topics/ activities/ lessons occurred in the three science lessons prior to this lesson? What topics/ activities/ lessons will be covered in the three science lessons following this lesson?) All blanks should be completed and** answers should be based on the teacher's interpretation of the lesson, not the coach's.
Y = yes, the lesson includes this criteria, N = no, the lesson does not include this criteria, DK = participant indicates they either don't know what the criteria means or whether the lesson meets the criteria

	Days Preceding				Days Following		
	Day 1	Day 2	Day 3	Today	Day 1	Day 2	Day 3
Topic(s)							
Activities		.	.			.	
Problem-based Learning?							
Nature of Science?							
Inquiry?							
Technology?							

Note: If you indicated "yes" for PBL, NOS, Inquiry, Tech briefly describe below what made it (why you think it is) a PBL/NOS/Inq/Tech lesson.

C. **Classroom setting. Describe anything about the classroom layout that would constrain the teaching of science.**
D. **Other relevant details about the time, day, students, or teacher that you think are important? (i.e.: teacher bad day, day before spring break, pep rally previous hour, etc.)**

Section III. Description of events over time (indicate time when the activity changes). **(You may complete this section or include the notes you took on this lesson.) Make sure that you describe the activity.**

Time	Description of events

Please attach any other documentation from the classroom observation.