How to Submit Proof Corrections Using Adobe Reader

Using Adobe Reader is the easiest way to submit your proposed amendments for your IGI Global proof. If you don’t have Adobe Reader, you can download it for free at http://get.adobe.com/reader/. The comment functionality makes it simple for you, the contributor, to mark up the PDF. It also makes it simple for the IGI Global staff to understand exactly what you are requesting to ensure the most flawless end result possible.

Please note, however, that at this point in the process the only things you should be checking for are:

- Spelling of Names and Affiliations
- Accuracy of Chapter Titles and Subtitles
- Figure/Table Accuracy
- Minor Spelling Errors/Typos
- Equation Display

As chapters should have been professionally copy edited and submitted in their final form, please remember that no major changes to the text can be made at this stage.

Here is a quick step-by-step guide on using the comment functionality in Adobe Reader to submit your changes.

1. Select the Comment bar at the top of page to View or Add Comments. This will open the Annotations toolbar.

2. To note text that needs to be altered, like a subtitle or your affiliation, you may use the Highlight Text tool. Once the text is highlighted, right-click on the highlighted text and add your comment. Please be specific, and include what the text currently says and what you would like it to be changed to.
3. If you would like text inserted, like a missing comma or punctuation mark, please use the **Insert Text at Cursor** tool. Please make sure to include exactly what you want inserted in the comment box.

4. If you would like text removed, such as an erroneous duplicate word or punctuation mark, please use the **Add Note to Replace Text** tool and state specifically what you would like removed.
Exploring the Effectiveness of Online Education in K–12 Environments

Tina L. Heafner  
*University of North Carolina at Charlotte, USA*

Richard Hartshorne  
*University of Central Florida, USA*

Teresa Petty  
*University of North Carolina at Charlotte, USA*
Section 1
Issues, Challenges, and Trends in Quality Online K-12 Education

Online learning, while pervasive in higher education, is becoming more prevalent in K-12 settings. The rapidity of technological change in the last decade has raised awareness of the gap between ubiquitous technology usage in personal lives and the more static, traditional schooling practices. Online courses and virtual schools are emerging as a go to option in K-12 settings to innovative practices and integrate contemporary technologies, while also addressing increasing class sizes, shrinking budgets, and growing student populations. With new platforms and spaces for learning come questions about quality assurance that these innovations effectively support student learning outcomes. The first section of this book examines the issues, challenges, and trends associated with quality online K-12 Education.

Chapter 1
Online Learning in Illinois High Schools: The Voices of Principals! ........................................ 1
Anthony G. Picciano, City University of New York (CUNY), USA
Jeff Seaman, Babson College, USA
Scott L. Day, University of Illinois – Springfield, USA

This chapter reports the results and implications of a study with the purpose of examining the role that online learning was playing in addressing the thoughts, concerns, and issues facing Illinois high school principals. Data was collected from a sample of high school principals with respect to the extent, nature, and reasons for participating in online learning programs. An important aspect of this study was to compare the findings in Illinois to those collected from a national sample of high school principals. Authors discuss their conclusion that online and blended learning are making inroads into the high schools in Illinois comparably to those in other parts of the country. The results of this study indicate that online and blended learning are becoming integral to a number of high school reform efforts, especially with regard to improving graduation rates, credit recovery, building connections for students to their future college careers, and differentiating instruction.
Chapter 2
Challenges, Opportunities, and Trends in Quality K-12 Online Environments

Marius Boboc, Cleveland State University, USA

This chapter provides background information related to K-12 online education, ranging from definitions to benefits and challenges. An in-depth analysis of the virtual learning landscape reveals the multitude of dimensions by which it could be evaluated, including the range of programs, service provider types, approaches to blended learning, kinds of instruction delivery, as well as levels of interaction within cyberspace. A proposed theoretical framework identifies academic programs/curricula, student support services, and virtual program/school administration as categories that connect the relevant literature review to recommendations for future research intended to inform policy-setting efforts aimed at supporting the further development of high quality K-12 online environments.

Chapter 3
Meeting the Demand for Online Education: A Study of a State-Run Program Designed to Train Virtual K-12 Teachers

Jayme Nixon Linton, Lenoir-Rhyne University, USA
Wayne Journell, University of North Carolina – Greensboro, USA

Although K-12 online education is becoming more common in the United States, the research base is still lagging behind. The field’s understanding of how K-12 online teachers are being prepared is especially sparse. Given that few teacher education programs include online pedagogy in their teacher training efforts, it becomes incumbent on states to find alternative ways to prepare teachers for virtual instruction. This chapter analyzes a 9-week orientation session that is part of an established, state-run induction program for prospective K-12 online instructors. Although the findings are specific to the program being studied, the authors propose that the program can serve as a model for educators in other states wishing to develop similar types of induction programs and for teacher education programs that will eventually have to incorporate online pedagogy into their existing programs in order to meet the rising demand for K-12 online instruction in the United States.

Chapter 4
Unbounded Reading: Why Online Learning for K-12 Students Should Be a Literacy Issue

Dixie D. Massey, University of Washington, USA

Students’ reading ability and achievement are the focus of numerous national and international reports. At the same time, research on K-12 distance education offers a very limited description of the types of reading that students are asked to do or the students’ abilities to accomplish this reading effectively. This chapter overviews the limited research about reading in online courses. The author then examines the potential of reading in online courses through bounded and unbounded contexts. The chapter concludes with a discussion of instructional opportunities for teachers of online courses when designing reading assignments.
Section 2

K-12 Online Course Development and Instructional Design

While online learning in K-12 environments continues to increase in popularity, there has been little attention given to design and development issues that must be addressed when transitioning from face-to-face instructional settings to virtual instructional settings. Consequently, the quality of online K-12 experiences often vary significantly. Additionally, K-12 course designers are frequently not well versed in design and development issues specific to online K-12 settings. Thus, as online K-12 learning continues to grow, there is an emerging need for disseminating best practices in the design, development, and implementation of online K-12 instructional settings. The three chapters in this section begin this discussion through extensive examination of issues to consider and approaches to take throughout the design and development process.

Chapter 5

Practical Guidelines for Creating Online Courses in K-12 Education ................................................................. 90
Wayne Journell, University of North Carolina – Greensboro, USA

Online learning is the future of K-12 education. However, few online K-12 instructors have been formally trained in online pedagogy. This chapter describes best practices in creating online courses for K-12 students. Many aspects of online learning are the same regardless of the age of the students taking the courses, but adolescents often experience online instruction differently than university students or adult learners. Thus, this chapter describes basic guidelines and offers recommendations for K-12 educators wishing to create engaging online learning opportunities for their students.

Chapter 6

Synchronous Text Chat (EduTexting) as an Online Learning Tool ................................................................. 112
Tina Heafner, University of North Carolina – Charlotte, USA
Michelle Plaisance, Greensboro College, USA

The increasing popularity and accessibility of affordable computer-mediated communication is rapidly advancing alternative forms of message transmission into market sectors, such as education. The focus of this chapter is an exploratory multi-case study of rich learning experiences of participants enrolled in three online courses who engaged in computer-mediated dialog. The researchers examined collective and individual use of synchronous text chat for the purpose of understanding learner and instructor social and cognitive presence, as well as attitudes toward online learning. Through a content analysis, researchers found that this mode of communication unilaterally enriched the observation learning experience for all participants. Specifically, researchers identified four meaningful social and cognitive functions of the synchronous text chat: a) enhancing enjoyment, b) engagement and noticing, c) achieving community and providing interactive immediacy, and d) bridging of theory to practice. Researchers coined this use of SMS (synchronous texting) in academic settings EduTexting and argue for its application in future K-12 online courses. Based on the findings of this study, the authors conclude there are significant educational benefits to using a form of communication that is congruent with students’ lives.
Chapter 7
Learning Theory and Online Learning in K-12 Education: Instructional Models and Implications.

Alex Kumi-Yeboah, University at Albany – SUNY, USA

In the United States, online learning in K-12 schools is growing rapidly. It is estimated that in the school year 2012, more than 1.5 million students at the K-12 level participated in some form of online learning. Teachers use technology on a daily basis to deliver instruction, analyze data of students and assessment, as well as differentiate instruction to promote and engage students in deeper learning and mastery of concepts. However, several questions need to be asked regarding the application of learning theories in online learning and how this application impacts student learning. While online learning has the ability to promote rapid growth of student academic performance using instructional strategies such as differentiated instruction, less is known about the integration of learning theory and online learning in K-12 schools and its impact on student learning. This chapter seeks to analyze the integration of learning theories and online learning and its effects on student academic performance by examining the trends of online learning in K-12 schools.

Section 3
Instructional Models in K-12 Online Teacher Education

Online course offerings are growing in popularity in both K-12 and higher education settings. As the number of offerings of online courses and programs continues to expand, preparation of those teaching virtually become more and more important. The third section of this book seeks to offer a foundation for teacher preparation in online classrooms while providing various instructional models to improve the quality of professional development.

Chapter 8
Effective Online Learning Begins with Effective Teacher Preparation

Laura Corbin Frazier, Mount St. Mary’s University, USA
Barbara Martin Palmer, Mount St. Mary’s University, USA

This chapter provides a description of four models for professional development for online instruction and analyzes each model according to clearly defined domains of effective online instruction, including faculty stance, student self-regulation, faculty support, authentic practice, engagement, community development, and cognitive demand. Subsequent to model analysis, a decision model is provided for K-12 and university administrators, teacher educators, and policy-makers to guide strategic decision-making in the determination of a model for professional development best suited to the needs and resources of their institution.
Chapter 9
The Ever-Evolving Educator: Examining K-12 Online Teachers in the United States

Jean Larson, Arizona State University, USA
Leanna Archambault, Arizona State University, USA

This chapter reviews the current research on the educational, training, and demographic characteristics of those involved in teaching K-12 online. Although very few colleges of education incorporate any aspect of teaching online into their curricula, the existing online teacher preparation programs are discussed. Past and ongoing research reveals a dramatic disconnect between: (a) the rapidly expanding expectations for and implementation of online education at the K-12 levels, and (b) the surprisingly limited extent to which teachers are actually being educated, trained, and otherwise prepared to function in this challenging new educational environment. The implications for teacher education programs and current K-12 virtual schools are clear. Effective online teaching techniques must be defined, empirically proven, and efficiently implemented by both future and current K-12 online teachers.

Chapter 10
Online Learning in K-College Classrooms: Students and Teachers Establish Social, Cognitive, and Teaching Presences in Digital Spaces

S. Michael Putman, University of North Carolina – Charlotte, USA
Brian Kissel, University of North Carolina – Charlotte, USA
Jean Vintinner, University of North Carolina – Charlotte, USA
Amy J. Good, University of North Carolina – Charlotte, USA

The rapid expansion of technology within educational contexts has created a situation where teachers are increasingly asked to find ways to use technology to allow learners to interact authentically with content and other users. This often encompasses some form of online instruction; yet not all teachers feel prepared to engage in online teaching. To address this context, this chapter identifies various elements of design that have proven effective within online instruction. To expand upon these elements, the Community of Inquiry (CoI) framework is introduced. The chapter further describes how the CoI’s social, cognitive, and teaching presences can be used to create an environment conducive to learners’ active engagement with content and each other. The chapter concludes with descriptions of specific activities integrating the presences that can be used to facilitate learning in online environments as well as implications for future research in this area.
Chapter 11
Establishing a Mentoring Relationship between Pre-Service and Mentor Teachers through Windows into Teaching and Learning

Teresa Petty, University of North Carolina – Charlotte, USA
Tina L. Heafner, University of North Carolina – Charlotte, USA
Abiola A. Farinde, University of Pittsburgh, USA
Michelle Plaisance, Greensboro College, USA

Windows into Teaching and Learning (WiTL) was a project designed by researchers at one southeastern US university that allowed the facilitation of online clinical experiences for graduate interns during their content area methods course. WiTL was originally developed to address challenges in providing meaningful clinical experiences for interns during online summer coursework. In providing these experiences, a mentoring relationship emerged between the participating practicing and pre-service teachers. This chapter reports the results of a study that explored those relationships and how they were fostered by the unique features of WiTL, which included online threaded discussions, synchronous and asynchronous viewings of classroom instruction, and text chat communication. The potential for programs like WiTL to be implemented in PK-12 settings is also discussed.

Section 4
Transitioning from Face-to-Face to Virtual K-12 Learning Environments: Emerging Technologies and Promising Pedagogical Practices

While technology has forever changed the ways in which both students and teachers experience learning opportunities, the current knowledge base related to transitioning from traditional face-to-face to virtual K-12 environments is limited. These new ways of facilitating learning experiences require thoughtful reconsideration of existing epistemological beliefs and practices. The five chapters in this section discuss various methods of using pedagogical approaches and both traditional and emerging technological tools to support the transition from traditional face-to-face K-12 learning environments to blended and online K-12 learning experiences. As the trend for growth in online learning continues at an accelerated pace, the insights shared from these authors are important lessons to consider as online learning becomes even more pervasive in K-12 settings.
Chapter 12
Providing Elementary and Middle School Science Teachers with Content and Pedagogical Professional Development in an Online Environment

Mary V. Mawn, SUNY Empire State College, USA
Kathleen S. Davis, University of Massachusetts – Amherst, USA

There is a great need to provide science teachers with on-going and relevant professional development, but access to such opportunities can be challenging due to time, distance, and budget pressures. Online courses and programs can provide alternatives to address these challenges. This chapter presents approaches, findings, and recommendations for online professional development of elementary and middle school science teachers based on a case study of an online science education course and an online chemistry course. Three themes are discussed: the ability to incorporate inquiry-based teaching and learning in online environments, the importance of online discourse and reflection, and the role of linking theory with practice. Teacher participants reported increased experience exploring content via inquiry, felt actively engaged with their peers as they constructed their knowledge, and expected to adapt inquiry-based activities in their classrooms as a result of these online courses.

Chapter 13
Challenges and Opportunities in the First Year of a 1:1 iPad Initiative in a High-Poverty, Highly Diverse Urban High School

Gayle Y. Thieman, Portland State University, USA

The digital divide between technology-mediated instruction for students in low versus high socio-economic schools is a serious equity issue with repercussions for student learning. While there is a growing body of research on blended learning and 1:1 mobile devices, there seems to be little research on the potential of iPads to reduce disparity of access and impact student learning in high poverty schools. This chapter reports first year results of a 1:1 iPad project on teachers’ attitudes and experiences and on high school students’ technology access and use. Using iPads resulted in blended learning opportunities for some, but not all students. Those who had an individually assigned iPad to use at school and home reported significantly higher satisfaction and proficiency with technology, while also reporting significantly greater use of online iPad applications and technology activities for instruction both during class and outside of school.

Chapter 14
Teaching History in the Digital Age

Scott M. Waring, University of Central Florida, USA

It is undeniable that students today are fundamentally different than those of previous generations and that many students of this generation do not enjoy history, as it is typically ranked as one of the least favorite subjects in K-12 schools. A large reason for this is the fact that much of the curriculum and approaches with which they are presented are outdated and of little interest to our student population and does not mirror the approaches and methods employed by historians in the field. The College, Career, and Civic Life (C3) Framework for Social Studies State Standards is an excellent model of inquiry oriented-learning for history educators to utilize as they prepare students for college, career, and civic life. This chapter focused on ways that educators, in a mixed-mode or online environment, can attend to the four dimensions of the C3 framework, specifically focusing on how to assist students in evaluating sources and using evidence, developing questions and planning inquiries, applying disciplinary concepts and tools, and communicating conclusions and taking informed action.
Chapter 15
3D Multi-User Virtual Environments in Science Education: Potential and Challenges

Yufeng Qian, Northeastern University, USA

US students are lagging behind in science literacy and the nation is falling short in science education. To address this significant crisis in science education, many research attempts have been undertaken to explore how to make optimal use of the emerging three dimensional multi-user virtual environment (3D MUVE) technologies to improve K-12 science teaching and learning. The purpose of this chapter is to identify the potential and challenges in the use of this emerging technology in science education through reviewing existing 3D MUVE science programs. These programs have demonstrated a number of instructional benefits in motivating and engaging students and in improving their science learning and scientific inquiry. Clearly, 3D MUVE is a promising media in narrowing gender and racial achievement gaps and enabling an authentic and valid assessment of science education. Like all new instructional technologies; however, the wide use and implementation of 3D MUVE technology in mainstream science classroom at present is still facing a number of challenges, which are mainly related to technological complexity and cost, and design difficulty in incorporating some elements critical to inquiry-based learning into the 3D MUVE environment. To overcome these identified challenges and make optimal use of the opportunities, suggestions on integration of 3D MUVE into science curriculum and classroom are made and discussed, along with future research directions.

Chapter 16
Online Discussion Boards in the Constructivist Classroom

Lauren Lunsford, Belmont University, USA
Bonnie Smith Whitehouse, Belmont University, USA
Jason Lovvorn, Belmont University, USA

The purpose of this chapter is to provide preservice and practicing teachers a constructivist lens for viewing how they use technology, specifically online discussion boards, in their face-to-face, blended, and online classrooms. The chapter introduces the idea that online discussion boards present a unique opportunity for constructivist teachers, in particular, and then provides several specific and practical strategies for ways to use discussion boards in the face-to-face, blended, and online classroom, addressing strategies connected to the roots of constructivist beliefs. In particular, this chapter highlights the role that writing can play when using online discussion boards in varied settings.

Section 5
Examining Issues of Diversity in Online K-12 Teaching and Learning

An emergent theme in these final chapters was the differences that students and teachers bring to the online learning environment and how these differences should inform virtual program, course, and instructional design. Three chapters address strategies for harnessing the value of diversity among participants and the perceptions teachers bring into their instruction. Collectively they promote a culturally responsive and gender sensitive approach to online teaching and learning. The uniqueness of students and teachers should be seamlessly integrated in virtual tasks and online curriculum.
Chapter 17
Best Pedagogical Practices for Acknowledging and Accommodating Diversity in Online Courses

Christina Nash, University at Albany, USA

This chapter examines the best practices for acknowledging and accommodating diversity in online courses, focused at the K-12 level. It presents the challenges of a culturally biased internet and offers possibilities for educators to address this bias, not only for themselves as pedagogical and instructional designers, but also for their students in both online and blended learning environments. While understanding cultural learning biases is important in any online education setting, teachers at the K-12 level need to be especially vigilant as they are working with students who are still developing their own identities as both people and learners. Strategies recommended include, but are not limited to, being aware of cultural differences through both information gathering and experience, providing opportunities for communication that honor student learning preferences, providing explicit course guidelines, expectations, and extended descriptions of course assignments, addressing the implementation of collaborative work with students of diverse backgrounds, and promoting student’s cultural awareness through content and instruction.

Chapter 18
The Integration of Culturally Relevant Pedagogy and Project-Based Learning in a Blended Environment

Daniel Kelvin Bullock, North Carolina State University, USA

The use of blended learning environments is rapidly expanding in education. This chapter reports the results of a qualitative case study examining a teacher’s enactment of the New Tech Network educational model, which utilizes a blended learning environment, and the teaching strategies used to engage students and gauge student achievement. Detailed teacher interviews, classroom observations, and analyses of student assignments were the sources of data for the study reported. The findings centered on the integration of culturally relevant pedagogy and authentic instruction within this learning environment and the implications of this integration. The chapter concludes with recommendations for future research, including a more expansive study of the use of blended learning in social studies and different means of integrating culturally relevant pedagogy and authentic instruction into blended learning.
Chapter 19
High School Teachers’ Gender-Oriented Perceptions of Technology Integration

Tina L. Heafner, University of North Carolina – Charlotte, USA
Eric Groce, Appalachian State University, USA
Elizabeth Bellows, Appalachian State University, USA
Heather Coffey, University of North Carolina – Charlotte, USA
Mette Evelyn Bjerre, University of North Carolina – Charlotte, USA

Within social studies, researchers note limited attention has been given to examining gender differences associated with technology integration, and have called for increased dialogue regarding gender-related technology issues. In response, this chapter reports the results of a study that explores the gender divide in secondary teachers’ perceptions of effective technology integration. Using a qualitative research design, this study provides insight into social studies teachers’ perceptions of their pedagogical practices and technology integration. The purpose of this study is to develop an understanding of the differences in male and female teachers’ use of technology to teach and support student learning. Consideration of how technology is associated with gender-sensitive pedagogical thinking and practice may address the aforementioned gap in technology usage in social studies. Patterns uncovered in data analysis suggest that gender plays a critical role in social studies technology integration. The results from this study can inform methods in which technology is integrated into future social studies classrooms, particularly in emerging areas such as online courses.

Compilation of References

About the Contributors

Index
About the Contributors

**Tina Heafner** is a Professor in the Department of Middle, Secondary, and K-12 Education at the University of North Carolina at Charlotte. She earned her PhD in Curriculum and Instruction from the University of North Carolina at Greensboro. At UNC Charlotte, her administrative responsibilities include directing the College of Education Prospect for Success, and she earned her MEd in Secondary Education with a Minor in Secondary Education. Tina’s teaching and research focuses on effective practices in social studies education such as professional development schools, technology integration, content literacy development, and service learning. Her other research interests include policy and curriculum issues in social studies and content-based online teaching and learning. Her publications include four co-authored books and three edited books. She has published numerous articles in peer-reviewed journals such as *Teacher's College Record, Educational Researcher, Kappa Delta Phi, Theory and Research in Social Education, Journal of Technology and Teacher Education, Teacher Education and Practice,* and the *Journal of Digital Learning in Teacher Education.*

**Richard Hartshorne** is an Associate Professor and the Instructional Design and Technology Program Coordinator at the University of Central Florida. He earned his PhD in Curriculum and Instruction from the University of Florida. At the University of Central Florida, his teaching focuses on the integration of technology into the educational landscape, as well as instructional design and development. His research interests primarily involve the production and effective integration of instructional technology into the teaching and learning environment. The major areas of his research interest are rooted in online teaching and learning, technology and teacher education, and the integration of emerging technology into the k-post-secondary curriculum.

**Teresa M. Petty** is an Associate Professor in the Department of Middle, Secondary, and K-12 Education at the University of North Carolina at Charlotte. She also serves as the department’s coordinator of online programs. Teresa earned her EdD in Curriculum and Instruction from the University of North Carolina at Chapel Hill. At the University of North Carolina at Charlotte, her teaching focuses on instructional design, teacher leadership, and instructional methods in the middle and secondary mathematics classroom. Her research interests include teacher attraction/retention in high-need schools, online teaching/learning, and National Board Certification.

* * *
Leanna Archambault is an Associate Professor of educational technology at the Mary Lou Fulton Teachers College. Dr. Archambault’s research areas include teacher preparation for online and blended classrooms as well as the nature of technological pedagogical content knowledge. Most recently, she has collaborated on the Hartwell Education Initiative to create and study a newly developed blended course, Sustainability Science for Teachers. In 2010 and 2012, she won the Online Learning Innovator Award for Outstanding Research from the International Association for K-12 Online Learning. Prior to taking her position at Arizona State University, Dr. Archambault graduated from the University of Nevada Las Vegas with a PhD in instructional and curricular studies. As a former middle school English teacher, Dr. Archambault is passionate about improving the education, particularly through the use of relevant and emerging technologies.

Elizabeth Bellows is an assistant professor in the Department of Curriculum and Instruction at Appalachian State University in Boone, North Carolina. She teaches social studies methods courses in both elementary and secondary programs, and facilitates secondary social studies internships for undergraduates in local schools. Before her academic career, she taught in Texas public schools for nine years and supervised intern and student teachers for five years. Dr. Bellows has served in academic roles at the University of Texas at Austin and Stephen F. Austin State University and currently holds multiple leadership roles in regional, national, and international organizations in her field. Her research involves intersections of social studies and teacher education, historical research as it relates to social studies education, critical curriculum analysis, and international inquiry about social studies education in Japan and Romania.

Mette Evelyn Bjerre is a graduate student and research assistant in the Department of Sociology at the University of North Carolina at Charlotte. She is pursuing her MA degree in sociology and her main research interests include educational inequality, multiracial identity development, and race and ethnicity. For her MA thesis, Bjerre is analysing multiracial student interviews regarding persistence and belonging in STEM college majors. She graduated from Middlesex University in London, England, with a BA Honours in Politics and International Studies with Race and Culture and from Birkbeck College, University of London, England, with a MSc in Global Politics.

Marius Boboc is an Associate Professor of Education and Chair of the Department of Curriculum and Foundations in the College of Education at Cleveland State University. He has two undergraduate degrees from his native country of Romania – one in Accounting, the other in English. His graduate work was completed at Roosevelt University in Chicago and the University of Northern Iowa. His professional experiences correlate with his research interests along the lines of inquiry related to curriculum in a postmodern world, online teaching, learning, and assessment, accreditation, and supporting student learning to maximize access to college and/or career.
Daniel Kelvin Bullock graduated from North Carolina State University in 2013 with a PhD in Curriculum and Instruction and a concentration in Social Studies Education. He currently serves as the K-12 Social Studies Curriculum Specialist for Durham Public Schools in North Carolina. While serving in this capacity, he has implemented district-wide professional development to enhance social studies instruction, conducted workshops to assist teachers in developing cultural awareness and sensitivity, and created unit resources to support the instruction of the Common Core State Standards and the North Carolina Essential Standards. His research interests include social studies and literacy education, multicultural education, project-based learning, and technology integration.

Heather Coffey is an Assistant Professor in the Department of Middle, Secondary and K-12 Education at the University of North Carolina at Charlotte. Dr. Coffey’s primary teaching responsibilities include graduate English language arts methods as well as service-learning courses. Her research interests include ways to develop critical literacy with urban learners, bridging the gap between educational theory and practice in teacher education, and supporting in-service teachers in urban school settings through professional development.

Kathleen S. Davis is an Associate Professor of Science Education at the University of Massachusetts Amherst. She received her PhD in science education at the University of Colorado Boulder. Her research focuses on issues of gender and equity in science and science education, teacher education, and policy and reform. Her published manuscripts include: “‘Change is hard:’ What teachers are telling us about reform and teacher learning of innovative practices” (2003) in Science Education and “Fostering science education in an online environment: Are we there yet?” (2012) (with Will Snyder) in The Journal of College Science Teaching. Kathleen’s funded projects include: S2TLC: Supporting STEM Teaching and Learning through Communities, STEM Connections (GK12) and Science Education Online, all sponsored by the National Science Foundation. Each project engages K-12 science teachers in inquiry-based practices. Before her doctoral work, Kathleen taught 5th-8th grade science for 18 years in Illinois. She now teaches K-12 teachers.

Scott Day is an Associate Professor and Chair of the Department of Educational Leadership at the University of Illinois at Springfield. He holds an EdD in Educational Organization and Leadership from the University of Illinois at Urbana-Champaign. Dr. Day teaches courses on Instructional Leadership and Assessment for Learning online. The program was awarded Sloan-C Outstanding Program of the Year in 2010. In 2010, Dr. Day was awarded the Pearson Faculty Award for Outstanding Teaching at the University of Illinois at Springfield. Dr. Day has published on a Design-Based Approach to Improving Online Courses, Using Peer Review and Analytics: From Incremental Course Changes, Developing Communities of Inquiry in Online Courses, and most recently, Pedagogical Approaches to Massive Open Online Courses (MOOCs).
**Abiola A. Farinde** is a Post-doctoral Research Associate for the University of Pittsburgh’s Center for Urban Education. She received her doctorate degree from The University of North Carolina at Charlotte in Curriculum and Instruction with a focus on Urban Education. Prior to obtaining her PhD, she received a Bachelors of Arts degree in English from Texas A&M University and a Masters of Education degree in Administration from Lamar University. Her research interests include teacher education, educational policy, urban education, and gender and feminism.

**Joseph R. Feinberg** serves as an Associate Professor of social studies education at Georgia State University (GSU). Prior to joining the faculty at GSU, he taught secondary economics, history, and geography where he developed a passion for simulation games and experiential learning. Feinberg actively researches and publishes scholarship on simulation games, civic education, and teacher education. He also serves as Associate Director for the GSU Center for Business and Economic Education.

**Laura Corbin Frazier** is an Assistant Professor of Education at Mount St. Mary’s University. She holds an EdD in instructional technology from Towson University. Dr. Frazier specializes in distance education and technology integration in schools. She teaches courses at both the undergraduate and graduate level including foundations of instructional technology, distance education, and STEM methods. Her research focuses on the integration of technology in K-12 classrooms and in preservice teacher internships. Her recent work analyzes teacher technology decision-making in one-to-one computing environments, technology integration during preservice teacher internships, and the use of distance education in teacher education programs. She is also active in professional development schools having supervised elementary and secondary education teacher candidates and engaged in PDS research.

**Amy Good** is an Associate Professor in the Reading and Elementary Education Department at the University of North Carolina at Charlotte. Her areas of research include social studies methods and the integration of technology to enhance methods instruction. Dr. Good currently serves as Coordinator of the Elementary Education Program at UNC Charlotte.

**Eric Groce** is an Associate Professor at Appalachian State University in Boone, North Carolina where he teaches courses in elementary level (K-6th) social studies. His research interests include children’s trade book analysis, teacher content knowledge, civilian life during World War II, and educational applications of technology within the social studies classroom. He has published articles in *Social Education, Middle Level Learner, Social Studies and the Young Learner, Social Studies Research and Practice, Journal of Critical Inquiry into Curriculum & Instruction, Reading Horizons,* and *Education Research and Perspectives*. In addition, he is currently finishing a nonfiction picture book about the North Platte Canteen, an oasis of hospitality for soldiers riding the Union Pacific rails on the way to their wartime assignments.

**Wayne Journell** is an Assistant Professor and Secondary Social Studies Program Coordinator at the University of North Carolina at Greensboro. He maintains research interests in secondary social studies education and K-12 online education. His research in the latter category has been published in *Phi Delta Kappan, Theory and Research in Social Education, Educational Media International, E-Learning,* and multiple book chapters. He is also the author of *Online Learning: Strategies for K-12 Teachers* (Rowman & Littlefield, 2013).
Brian Kissel is an Associate Professor in the Reading and Elementary Education Department at the University of North Carolina at Charlotte. His areas of research include early writing acquisition, early childhood writing pedagogy, digital literacy, and literacy coaching.

Alex Kumi-Yeboah has a PhD in Curriculum and Instruction and an MAT (Masters of Arts in Teaching) in Social Sciences Education from the University of South Florida, and is an assistant professor at Dalton State College. Kumi’s areas of research include instructional technology, distance, online, and blended learning in the developing world, multicultural education, teacher education preparation, literacy studies, and transformative learning. He has extensive experience as a champion for students of color both at his home institutions and in his communities.

Jean Larson has a PhD in educational technology from Arizona State University, where her research has focused on K-12 online education and the corresponding areas of teacher preparation and training. She holds a BA in education from the University of Redlands, CA and a MEd in elementary education from Northern Arizona University. Dr. Larson has taught at the K-12 levels in California, Arizona, and internationally. Over the past ten years she served as an education and training consultant for various industries, including healthcare, education, public services and technology through Aspen Research, Ltd. and other organizations in the United States and abroad.

Jayme Linton serves as Director of the Masters of Science in Online Teaching and Instructional Design program at Lenoir-Rhyne University in Hickory, North Carolina. Previously, she held positions as Instructional Technology Facilitator, Staff Development Coordinator, and Instructional Coach for Newton-Conover City Schools. Jayme is a doctoral candidate in the Teacher Education and Development PhD program at the University of North Carolina at Greensboro, with a focus on instructional technology. Jayme was recognized by the National School Board Association as one of the “20 to Watch” for 2012-13 and was a recipient of the ISTE Making IT Happen award, presented by NCTIES in 2013. Jayme is the co-founder of #edteach, a bi-weekly Twitter chat for pre-service teachers and #NCed, a bi-weekly Twitter chat for North Carolina educators.

Jason F. Lovvorn is an Assistant Professor of English at Belmont University in Nashville, Tennessee where he teaches composition and rhetoric. His writing classes address themes such as literacy, technology, and the natural world, and many of his classes involve a service commitment to the Nashville community. His research interests include writing, literacy, new media, service-learning, and higher-education pedagogy, and he has published work regarding service-learning narratives, digital storytelling, online gaming, and literacy history.

Lauren B. Lunsford is an Associate Professor of Education at Belmont University in Nashville, TN. She earned her MEd and PhD in Special Education at Vanderbilt University and has worked with students at the elementary, middle, and high school level. Her research interests include literacy issues, especially for at risk students, educational technology, and interdisciplinary instruction. Her classes include those that focus on literacy, best practices in the K-12 classroom, and the role of adolescent and human development in the classroom.
About the Contributors

**Dixie D. Massey** teaches face-to-face courses at the University of Washington and online courses for The University of North Carolina at Greensboro and East Carolina University. Her research interests include effective instruction for struggling readers, disciplinary literacy, and teacher research. Her articles have appeared in such publications as *The Reading Teacher, Reading Research and Instruction, The Journal of Adolescent and Adult Literacy, and The Journal of Literacy Research*. She is the co-author of the curriculum series, *Comprehension Strategies for World History and U.S. History in the Social Studies, Targeted Vocabulary Instruction in Social Studies: Tools for Academic Achievement*, and *Seeds of Inquiry: Using Short Text to Support Reading Comprehension in U.S. History*. She currently serves as Historian for the Literacy Research Association.

**Mary V. Mawn** is an Associate Professor and Academic Area Coordinator in Science, Mathematics, and Technology at the Center for Distance Learning, SUNY Empire State College, Saratoga Springs, NY. She teaches on-site and online courses in microbiology, genetics, molecular/cellular biology, and science education. Dr. Mawn earned a BS in Biochemistry from the College of Mount Saint Vincent, NY, and a M.Ed. in Educational Technology and a PhD in Molecular and Cellular Biology from the University of Massachusetts-Amherst. Her research interests focus on identifying ways to teach scientific process skills in online science courses and promoting the online professional development of K-12 science teachers. Her research on online science inquiry, “Hands-on and Online: Scientific Explorations through Distance Learning”, is published in the journal *Open Learning* (Mawn, Carrico, Charuk, Stote, and Lawrence, 2011). In 2011, she was awarded a *Motorola Solutions Foundation Innovation Generation Grant* to develop six fully online undergraduate science courses.

**Christina M. Nash** is an advanced doctoral student and graduate assistant in the Department of Educational Theory and Practice (ETAP) at the University at Albany, SUNY. Christina’s areas of expertise include curriculum development and evaluation, instructional technology, and literacy. She has been an online instructor at the university for the past three years, teaching both graduate and undergraduate students in the ETAP department. Prior to beginning her doctoral studies, Christina was a public school teacher, and holds a New York State Professional Teaching Certification in English (7-12). She also spent four years as a professional writer and editor.

**Barbara Martin Palmer** is a Professor of Education and Dean of the School of Education and Human Services at Mount St. Mary’s University. She holds a PhD from the University of Maryland College Park. Dr. Palmer specializes in literacy education and teaches courses in the masters of education in reading program. A former high school Spanish teacher, Dr. Palmer has supervised secondary education teacher candidates as a middle school/high school professor in Residence. Her research interests include teacher change, professional development schools, and comprehension. Dr. Palmer represents higher education on the Professional Standards and Teacher Education Board for the state of Maryland.
Anthony G. Picciano is a Professor and Executive Officer in the PhD Program in Urban Education at the Graduate Center of the City University of New York. He is also a member of the faculty in the graduate program in Education Leadership at Hunter College, the doctoral certificate program in Interactive Pedagogy and Technology at the City University of New York Graduate Center, and CUNY Online BA Program in Communication and Culture. In 1998, Dr. Picciano co-founded CUNY Online, a multi-million dollar initiative funded by the Alfred P. Sloan Foundation that provides support services to faculty using the Internet for course development. He was a founding member and continues to serve on the Board of Directors of the Sloan Consortium. In 2010, Dr. Picciano was the recipient of the Sloan-Consortium’s National Award for Outstanding Achievement in Online Education by an Individual.

Michelle Plaisance is Assistant Professor and Director of TESOL at Greensboro College. Her research explores the education of language minorities in U.S. schools. Specifically, her research interests include the social context of schooling and how classroom practices, such as instructional ability grouping, impact the learning experiences of elementary-aged English learners. In addition to teaching students in pursuit of their Masters in TESOL, Michelle’s prior professional experiences includes teaching education courses for the University of North Carolina in Charlotte, working as an English as a second language teacher in PK-12 public schools, and instructing young adults in an intensive English program at the university level.

S. Michael Putman is an Associate Professor in the Reading and Elementary Education Department at the University of North Carolina at Charlotte. His areas of research include the impact of teacher preparation and professional development on teacher self-efficacy, including efficacy for classroom management, middle school student dispositions toward online inquiry, and the effective use of technology within teaching practices and for improvement of student outcomes.

Yufeng Qian is a faculty member in the Doctor of Education program at Northeastern University. She teaches courses in quantitative research design and data analysis and advises doctoral research studies. Her fields of research include emerging technologies, online education, and teaching effectiveness. Dr. Qian is the author of a number of book chapters and journal articles on 3D virtual learning environments, game-based learning, and digital media literacy. Prior to joining Northeastern University, Dr. Qian worked as an Associate Professor of Education at St. Thomas University, Miami, Florida. Her prior experiences in higher education include Dartmouth College, Grand Valley State University, Lehigh University, SUNY at Buffalo, and Beijing Capital University of Economics and Business.
Jeff Seaman is the Co-Director of the Babson Survey Research Group. He holds degrees in Demography/Statistics, Sociology, Electrical Engineering, and Housing, all from Cornell University. Dr. Seaman created and ran the Computing Resource Center and served as Associate Vice Provost for Computing for the University of Pennsylvania and as Chief Information Officer for Lesley University. His industry experience includes serving as Chief Technology Officer at HighWired.com, where he led the development of an online learning system and as the Vice President of Engineering for Vista Associates building course management systems. Dr. Seaman has served on academic technology advisory boards for a number of information technology companies including Apple Computer, IBM, and Microsoft. He has been conducting research in the impact of technology on higher education and K-12 for over a decade. His work includes the annual surveys on the state of online learning in US higher education, research into higher education faculty attitudes towards and adoption of technology, and faculty use of social media.

Gayle Thieman is an Associate Professor in the Graduate School of Education at Portland State University, Oregon. She teaches and advises pre-service teachers, specializing in social studies methods, curriculum and instructional design and instructional technology. Her current research includes evaluating the integration of iPads in secondary schools, examining school and community opportunities for civic engagement by K-12 students, and researching the integration of disciplinary literacy strategies by social studies pre-service teachers. Dr. Thieman was a middle and high school social studies teacher and administrator for 20 years and instructor in Teaching American History grants in Alaska and Oregon. She is a past president of the National Council for the Social Studies.

Jean Vintinner is a clinical Assistant Professor in the Department of Reading and Elementary Education at the University of North Carolina at Charlotte. A former high school English and reading teacher, her academic interests include adolescent literacy, content area reading, and motivating struggling readers.

Scott M. Waring is an Associate Professor and Program Coordinator for the Social Science Education Program at the University of Central Florida. He earned his BS and M. degrees in Education from the University of South Florida and a PhD from the University of Virginia in Social Studies Education, with a minor in Instructional Technology. Dr. Waring teaches courses at the undergraduate and graduate level in elementary and secondary social science education methodology, research, and theory and serves as the Director of the Teaching with Primary Sources Program at the University of Central Florida. He has written or co-written funded grants totaling over $3.6 million, including a Teaching with Primary Sources grant from the Library of Congress and three Teaching American History (TAH) grants. The teaching and learning of history and the utilization of technology in social studies education are the foci of Dr. Waring’s research and publications.

Bonnie Smith Whitehouse is an Associate Professor of English at Belmont University in Nashville, Tennessee. Her specialties are writing and rhetoric, and she earned her PhD in English at the University of Wisconsin-Madison; her doctoral minor was in Curriculum and Instruction. Her research and teaching focuses on ways reading and writing inform understandings of politics, nature, and identity. She has written previously about ways so-called common readers report reading popular novels have “changed” their lives in the context of mass literacy movements, and she is at work on a study stemming from her interest in walking, writing, and embodiment theory.
Chapter 12
Providing Elementary and Middle School Science Teachers with Content and Pedagogical Professional Development in an Online Environment

Mary V. Mawn
SUNY Empire State College, USA

Kathleen S. Davis
University of Massachusetts – Amherst, USA

ABSTRACT

There is a great need to provide science teachers with on-going and relevant professional development, but access to such opportunities can be challenging due to time, distance, and budget pressures. Online courses and programs can provide alternatives to address these challenges. This chapter presents approaches, findings, and recommendations for online professional development of elementary and middle school science teachers based on a case study of an online science education course and an online chemistry course. Three themes are discussed: the ability to incorporate inquiry-based teaching and learning in online environments, the importance of online discourse and reflection, and the role of linking theory with practice. Teacher participants reported increased experience exploring content via inquiry, felt actively engaged with their peers as they constructed their knowledge, and expected to adapt inquiry-based activities in their classrooms as a result of these online courses.

INTRODUCTION

Good teaching matters! According to the NAEd Education Policy White Papers Project, “there is persuasive evidence that students benefit from high quality instruction and that these benefits are cumulative for students who have good teachers for several years” (Wilson et al., 2009, p. 1). Thus, there is a great need to provide science teachers with on-going and relevant professional develop-
ment (PD). The Glenn Commission report, Before It’s Too Late (Department of Education, 2000), states that better mathematics and science teaching is grounded in improving the quality of teacher preparation and making continuing PD available. Having access to PD programs can be problematic. Teachers must deal with time and travel constraints and budget pressures, leaving little opportunity to pursue PD. However, online courses and programs can allow teachers to fit coursework into their schedules as they can be accessed at any time, from any place (Asbell-Clarke & Rowe, 2007). For some teachers, online coursework may be the only option for furthering their subject knowledge (McNall Krall, Straley, Shafer, & Osborn, 2009).

There is growing evidence supporting online PD (Clary & Wandersee, 2009; Davis & Snyder, 2012; McNall Krall et al., 2009), but developing an effective course involves more than putting notes and assignments online. This chapter will describe considerations and approaches for developing online PD courses for science teachers and how two online courses engaged teachers in inquiry, meaningful discourse, and making connections to their classroom practice.

BACKGROUND

The Importance of Inquiry-Based Professional Development

Science is not simply a collection of facts to be memorized and explained, but rather, it is a way of thinking and approaching real-world problems. Scientific inquiry is described as:

...a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. (National Research Council (NRC), 1996, p. 23)

 Students who engage in scientific inquiry use many of the same activities and thinking processes as scientists, yet these activities and processes are not always familiar to teachers (Olson & Loucks-Horsley, 2000). Since teachers’ knowledge, experiences, and beliefs greatly impact what takes place in the classroom, teachers should learn content and pedagogy through engagement in activities that mirrors the approaches it is hoped they will bring into their classrooms (NRC 1996; Loucks-Horsley, Stiles, Love, & Hewson, 2010).

PD should incorporate science practices that promote teachers’ understanding of science content and inquiry-based approaches (Capps, Crawford, & Constas, 2012). As with students, teachers learn best by doing science, investigating and constructing their understandings. Teachers should have significant and substantial involvement in laboratory experiences where they actively investigate phenomena, devise research questions, design procedures, collect and analyze data, and report findings (NRC, 1996).

PD that engages teachers in authentic research experiences and provides opportunities to develop inquiry-based lessons, may be key in assisting teachers in bringing such approaches to their classrooms (Capps et al., 2012). There is a need for rigorous, research-based PD for science teachers that empowers them to utilize the most effective science teaching methods, including unstructured problem-solving and inquiry-based learning (National Science Board, 2010).
The Value of Communication in Online Professional Development Courses

Effective online courses should actively engage educators and follow the basic principles of good teaching: encourages student-faculty contact and collaboration among students; provides prompt feedback; emphasizes time on task; communicates high expectations; and respects diverse talents and ways of learning (Chickering & Gamson, 1999). Many of these principles rely on open and frequent communication between the instructor and students and among course participants. Discussion boards, chat rooms, whiteboards, email, and assignment drop-boxes (with options to provide feedback) allow for multiple modes of interaction and opportunities for online communication (Asbell-Clarke & Rowe, 2007).

In general online courses use predominantly asynchronous discussions, which can build a sense of community, keep participants on task, break down difficult concepts, and encourage synthesis and analysis of materials (Offenholley, 2006). Discussions also provide unique opportunities for scientific inquiry due to their text-based and archivable nature (Asbell-Clarke & Rowe, 2007). These written exchanges make students’ thinking visible and is available for review, reflection, and reference. Learners can articulate their ideas and respond to classmates at their own pace, share and clarify ideas or observations, give and receive comments based on differing experiences and interpretations, and review and reflect on multiple exchanges (Harlen & Doubler, 2004).

Finally, online communities allow participants to feel part of a group with similar interests (Asbell-Clarke & Rowe, 2007). This sense of community can contribute to teachers’ overall success. Participants who feel connected often place a higher priority on, and devote more time to, course content and activities (Lee et al., 2004).

Connections of Online Professional Development to Classroom Practice

A key feature for effective PD includes deepening teachers’ content knowledge, including understanding how students learn and the difficulties they may encounter in mastering key concepts (Wilson et al., 2009). When surveyed, teachers enrolled in online science courses positively rated the value of online PD for furthering their knowledge in the subject areas they teach (Clary & Wandersee, 2009).

Likewise, fostering teachers’ use of instructional practices in the classroom is important (Desimone, 2011). Online courses should provide teachers with opportunities to develop learning materials that embed these practices and can be implemented in their classrooms.

Online Professional Development for Science Teachers

Based on the literature, we believe that a high-quality course for teachers (whether online or face-to-face) would require teacher engagement in inquiry-based activities, interaction between instructor-students and students-students, and links to classroom practice. As a result, in this case study we sought to describe the characteristics of one online science education (SE) course and one online chemistry course from the perspectives of elementary and middle school teachers. Specifically, in what ways did these online courses engage teachers in inquiry, meaningful discourse, and make connections to their classroom practice, and of what value was that to the course participants?

STUDY CONTEXT AND METHODS

Online Program and Study Site

Faculty collaborated to develop twelve online, graduate-level courses for in-service elementary
and middle school science teachers. These courses are tied to state and national standards and incorporate inquiry-based, hands-on experiences. Aided by kits of materials, teachers engage in guided and open-ended inquiries as they develop their understanding of science concepts. Discussions, journaling, and course activities provide multiple opportunities for interaction.

The SE instructors aimed to: introduce teachers to the nature of science through inquiry; help teachers identify the elements of inquiry teaching and learning; and explore the topics of conceptual learning, teacher questioning, and assessment as they relate to learning in the inquiry-based science classroom.

The chemistry instructors sought to: introduce teachers to the chemical and physical properties of matter; allow teachers to reinforce and extend their understanding of chemicals and their interactions; enable teachers to problem-solve and be aware of variables in experimental design; and examine the importance of pattern awareness in the learning process.

Each course was divided into twelve sessions. Course activities included readings, hands-on experiments, online discussions, lab notebook/journal, and quizzes. Course materials included textbooks, laboratory kit (chemistry), and online resources. The lab kit included materials needed to conduct hands-on experiments, with teachers supplying a small number of household items (e.g., food coloring, toothpicks, paper clips).

**Methods and Participants**

Study participants included the two science education instructors and six teachers enrolled during one semester, and two chemistry instructors and nine teachers enrolled during one semester. Ten teachers were female; five were male; six were elementary; nine taught at the middle-level. Two teachers had been teaching five or fewer years; 10 had 6-15 years of experience; and three had been teaching 20 or more years. Teachers taught in a variety of settings: urban, rural, and suburban.

Case study methods were used (Yin, 2009) to describe the online courses and the teachers’ participation in them. Case study methods are used when the researcher asks “how” or “why” research questions, seeking to explain or describe a present-day occurrence within a real-life setting that is bounded (Merriam, 1998) and where “relevant behaviors cannot be manipulated” (Yin, 2009, p. 11). This approach does not seek to report a causal relationship between a treatment and results. Rather, it is explanatory and descriptive of the occurrence studied (Merriam, 1998). Data sources included pre- and post-instructional surveys, interviews, and course artifacts.

Pre- and post-surveys were constructed to investigate participants’ beliefs and attitudes about science, teaching and learning. In addition, surveys provided demographic information, previous skills and experience with computer use, and informants’ experiences in course activities.

In-depth, semi-structured interviews (Merrim, 1998) provided insight into participants’ beliefs and attitudes about science, teaching and learning. In addition, surveys provided demographic information, previous skills and experience with computer use, and informants’ experiences in course activities.

In-depth, semi-structured interviews (Merrim, 1998) provided insight into participants’ beliefs and attitudes about science, teaching and learning. In addition, surveys provided demographic information, previous skills and experience with computer use, and informants’ experiences in course activities.

Course artifacts include students’ postings during weekly discussions, students’ journals documenting project work, course syllabi and weekly lessons and prompts.

Data sources were analyzed for evidence of inquiry, meaningful discourse, and connections to teachers’ classroom practice. Relevant patterns and themes were drawn based on the research questions (Merrim, 1998) and triangulated across the data sources. The analysis includes direct quotes, tables, and interpretive commentary. Pseudonyms were used throughout the analysis to maintain the informants privacy.
STUDY RESULTS AND FINDINGS

Key Themes

Three themes are discussed below, the importance of: incorporating inquiry-based, hands-on activities in online science courses; promoting online discourse and reflection; and bridging science content and teaching practice. Through teacher interviews, course artifacts, and pre- and post-surveys, these aspects are described, and teachers explained each element’s value.

Engaging in Inquiry-based, Hands-on Activities

The two courses in this study made extensive use of inquiry-based, hands-on activities. During a typical weekly session in the chemistry course, teachers engaged in two to four inquiry-based experiments. They conducted investigations individually and discussed their findings with their classmates. Three chemistry experiments were selected for in-depth analysis:

- The Fast, the Slow, the Big, and the Small: Teachers placed vanilla extract inside a balloon, inflated this balloon, and observed the states of matter;
- Taping the Charge: Teachers explored attractive/repulsive forces between adhesive tape placed under different conditions; and,
- Making “Cents” of Surface Tension: Teachers placed water on a penny and experimented with the cohesive forces of water under different conditions.

These experiments engaged teachers in various aspects of scientific inquiry (See Table 1). They explored, explained, and questioned the fundamental properties of solids, liquids, and gases. Teachers identified and tested variables while experimenting with attractive and repulsive forces. Finally, they developed investigations, made predictions, tested hypotheses and extended investigations as they explored cohesive forces. For example, one teacher recorded the details of the surface tension experiment in her journal as follows:

A clean, dry penny was placed on a paper towel. ...Prediction: ...40 drops will be the maximum before the water overflows off of the penny. 47 drops of the water were placed on the penny before the water overflowed. ...A clean dry toothpick was gently touched to the dome of water. It penetrated the dome of water without causing the water to overflow. Now the toothpick was dipped in liquid dish soap. When the toothpick touched the center of the water, the water flowed off of the penny.

Similarly, SE course participants engaged in a “rusty nail” activity— an open-ended, inquiry-based project. (See Table 1) The project opened with a question about one instructor’s eight-year-old pickup truck. After recently moving to Massachusetts, she found a hole, crusted with rust about the size of a quarter, on the bed of her truck. She hadn’t seen a sign of rust until that fall. As she showed them pictures of the hole in question, she questioned the group: “What caused this rusted hole? What is rust? What is the prognosis for my truck?”

After some discussion of what they knew about rust, the group was charged with making two nails, devoid of any protective covering, as rusty as possible. They designed their investigations, explored their questions around rust, submitted three Lab Reports based on their experiments, and recorded information about their investigations in a Science Journal. For example, Michelle noted in her journal her initial thoughts and questions about rust:

...road salt “eats” cars, fine sand and salty moist air is why we are advised to hose our cars off after a trip to the seacoast. What is the role of salt? How does it participate in the rust process?
Table 1. Teachers’ demonstration of inquiry skills

<table>
<thead>
<tr>
<th>Participant / Inquiry Descriptor</th>
<th>SE1</th>
<th>SE2</th>
<th>SE3</th>
<th>SE4</th>
<th>SE5</th>
<th>SE6</th>
<th>CH1</th>
<th>CH2</th>
<th>CH3</th>
<th>CH4</th>
<th>CH5</th>
<th>CH6</th>
<th>CH7</th>
<th>CH8</th>
<th>CH9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identifies questions that can be scientifically investigated</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Designs and conducts a scientific investigation</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Uses appropriate tools and techniques to gather, analyze, and interpret data</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Uses data to construct a reasonable explanation</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Communicates investigations and explanations</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Makes critical and logical connections between evidence and explanations</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Recognizes and analyzes alternative explanations and predictions</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Note: Inquiry Descriptors drawn from the NSES (NRC, 1996). SE1=Science Education Teacher #1; CH1=Chemistry Teacher #1; X = indicates skill present in teacher’s investigation postings and/or journal.

- I think if I scratch up one the nails to expose more surfaces to the salt water, that will encourage faster rusting. What am I going to scratch that small surface with? Another nail?
- Why am I thinking about this “expose more surfaces of the nail?” What do I think rust is and why do I think smaller or thinner pieces of metal will get rustier, or rust faster than a denser piece of metal?
- Why do I think that these nails are made of the same metal that cars are made of? What kind of metals are nails made of? And cars?
- If salt water will rust metal faster than fresh water, why are ships and boats that are made of metal allowed on the oceans?

Michelle designed and conducted her investigations. Below are excerpts from her journal, where
she describes her investigation, observations, and reflects on her results.

Lab 1: Rust Is a Sign of Neglect

- I put each nail in its own (expendable) saucer. One on the kitchen counter, one on the porch. Each nail sat in a puddle of water. In a few hours (If I knew rust happened so fast I would have measured the time then!), the inside nail was “bleeding rust”, outside nail was encased in ice, not rusty.
- Cold preserves nail. Warmth encourages evaporation, which seems to promote rust. Have to redo the experiment for time measure.
- Outside nail is slightly rusted, but took longer because snow and ice preserved nail. Inside nail needs more water added constantly. It is very cruddy, flaky, big rust. The rust on outside nail is fine textured, not nearly as extensive.
- Rust can be a sign of careful, deliberate care to cause rust. I want to think about “why salt” before I do salt. Also need more nails.

Lab 2: Only One Variable, and Only One Nail

Meantime, my experiment was limited to observations on the effect of temperature….

The problem is not having any way to measure, to explain how rusty the nails are or are not. This only: When cold tap water was used, the rust process was slower. (How slow?) The rust was finer. (How fine?) NOW: After the boiling water treatment, the rust is flakier. (How much flakier?) I BELIEVE the nail looks skinnier. (A caliper, do I need a caliper?)

Based on an analysis of discussion postings, online journals, and survey data, teachers painted a picture of learning science through “doing.” They discussed the benefits of conducting experiments individually and being able to confer with their online classmates. Through their investigations, teachers made predictions, designed and redesigned experiments, made observations, and ultimately drew conclusions about their studies. The ways in which the teachers engaged in the processes of scientific inquiry were evident in their postings and in the reports they recorded in their journals.

In a post-course survey, teachers enrolled in the chemistry course strongly indicated that inquiry methods were used. One teacher commented:

Almost every lesson…[was] inquiry based. Every week we had several labs or activities that involved concepts demonstrated through inquiry-based learning.

Another teacher wrote:

We collected data, analyzed it, [and] further investigated with questions of “wonder what would happen if”… [I]n some cases we were asked to search for answer[s] to questions that could only be found through investigation.

Another noted:

There were questions posed, and we followed activity directions, hypothesized on what we believed would happen, carried out the experiments, gathered data, made conclusions, and shared our results, and sometimes went back to …investigate…

A fourth stated: “Yes, [this] course definitely encouraged inquiry methods throughout all the lessons. As students, we were encouraged to ask questions, to develop an understanding and discuss our answers with our peers.” She provided this example:
You often do not think about what is happening to the atomic particles when you begin to smell a substance from the other side of a room, such as a turkey cooking in the oven. Yet, we did question the atomic movements of particles through the wall of a balloon. We asked questions and tested liquids such as vanilla extract and lemon juice among others in which we enclosed inside the sealed balloon. We could not see the substances dripping out anywhere, yet we could begin to smell the liquids within a few minutes. … We explored and analyzed the properties and behaviors of gases that we would then use as a foundation for new questions we asked throughout the course.

When asked how the activity-based nature of their course impacted the learning of science content, one teacher responded that “inquiry based activities really gave me a greater depth of understanding.” Another teacher commented: “the activities made me slow down a bit and take a more hands-on versus theory-only approach to learning science content.” A third teacher stated: “I have been able to remember most of the content because of the hands-on activities that allowed me to experience the learning.”

Promoting Online Discourse and Reflection

Online discussions played an important role in supporting teachers’ learning. Early in each course, teachers were asked to provide introductions and share information about their teaching contexts, course goals, and personal interests. Instructors fostered student interaction during each class session by asking teachers to respond to the posts of at least one or two other course participants. All postings and responses to posts were graded with a rubric.

As we analyzed their postings, we noted that teachers engaged with course concepts as they interacted online; participants’ exchanges provided guidance and clarification as teachers explored course topics, experienced new approaches, and considered ways to teach these concepts to their students; and teachers shared perspectives and approaches as they built on and extended their knowledge.

Teachers noted the benefits of discussing experimental findings with their classmates. During these online conversations, the teachers provided a summary of their experiments, formulated explanations based on their observations, responded to specific questions, and commented on their classmates’ postings. On a post-course survey one teacher commented:

The inquiry was all based on hands-on activities. It was an awesome experience to have everyone replicating the same experiment, and then actively discuss all of the viewpoints…[This experience gave] a real sense of not leaving any stone unturned.

In the excerpt below, four teachers in the chemistry course discussed what happened when vanilla was placed inside of an inflated balloon. This conversation highlights the constructive nature of online discussions as these teachers explored the states of matter:

Anna: …Matter changes states. I put a liquid into the balloon. A gas was smelled outside the balloon. …I can fill a balloon up with water and it doesn’t leak, but when I put vanilla or lemon extracts in the balloon I could clearly smell them. The gas molecules of those substances were fitting through the gaps in the balloon material. I put liquid extracts into the balloons, but clearly a gas or vapor was outside the balloon as part of the air mass. This is evidence of multiple states of matter of the same substance.

Brent: …I liked your example. …If the air molecules that were used to fill the balloon can’t fit through the openings of the balloon that allowed gas molecules of the vanilla extract
Providing Elementary and Middle School Science Teachers with Content and Pedagogical Professional Development in an Online Environment

to come out of, then why is it that eventually a balloon will slightly deflate?...

Anna: While I was writing that I had the same question. Perhaps there is greater attraction between liquid molecules than gas molecules. They tend to stick together and don’t slip through the holes while gas molecules are solitary creatures and can slip through?

Chris: I, too, was wondering the same thing...
I am thinking that the air molecules must escape over time. Perhaps this all relates to pressure, temperature, etc?...

Diana: …I think air molecules do get out over time, because they find their way between all of the nooks and crannies eventually...

These online discussions were an integral part of teachers’ investigations. In a post-course survey, one teacher from the chemistry course described the learning approach as “…read, discuss, experiment, discuss, report.” Another teacher commented on the benefit of online discussions:

The best part was the open discussions with other classmates. Someone always added a different perspective. It was a great way of learning, sharing ideas, and collaborating on our conclusions.

Based on the interview data, teachers in the SE course also noted that they were able to communicate ideas, feelings, and experiences and provide others with alternative ideas, critique, suggestions, questions, and encouragement. One teacher commented:

The actual back and forth was useful getting people’s comments - that was interesting….There was a diversity of experience and background among the [teachers]… Some were perhaps asking more sophisticated questions…but they were all…interesting questions. Interacting back and forth…you make connections between them….They would bring up questions you might not had thought of - that was useful….By encouraging everybody

to comment on everyone else’s questions and statements, encouraged people to really look at other people’s way of looking at things and that doesn’t happen often among peers and which you wouldn’t have necessarily done if [you] were in a regular (face-to-face) class.

Another stated:

I found myself asking questions of everybody. “...can you give me a really good idea” because I want to tap into the best ideas of everybody….I felt more grounded because some their stuff wasn’t working, or they had questions and I said “Oh thank God”, so now I can do something silly like that too and not feel bad. So I would say it was the inquiry part of that piece of it that was really important.

A third teacher noted:

I think everyone ran into problems...the encouragement made such a big difference. You don’t necessarily find that in every course that you take, and the atmosphere that was created was one of cooperation more than competition….I felt that really strong.

Michelle’s investigation experiences provided a good example of the problem-solving discourse. She described her struggle to quantify the rusting of the nails. In her journal, she noted how, missing this element, she found her investigation scientifically wanting. She stated:

All the teachers are designing their own experiments and doing them, and commenting on each other’s variables, and controls, observations, conclusions, and questions. These are mine, so far. They are not what I would call the most scientific…some of the other teachers’ experiments are more scientific than mine. Why? Because I didn’t measure measurable things, like how much time, how much water, the exact temperature.
Course participants and instructors responded to Michelle’s queries about how to measure the rust on her nails. Below are their comments:

Mary: I, too, am looking for a way to quantify the degree of corrosion; a fine scale before and after? scraping off the rust and weighing that? I am open to ideas. I am currently estimating it crudely by the depth of the sediment on the bottom of the jars, but that is pretty rough…..I, too, have trouble trusting my experimental technique and design. I keep thinking of things I forgot to control…).

Carrie: You say you have a problem, not being able to measure or describe how rusty a nail is... Is this a good next idea to focus on as you plan your further rusty nail investigations? Could you create a descriptive scale upon which you could rate your nails? An interesting idea!

David: Carrie’s suggestion is a good one. How can we set up a scale of “rustiness.”

Michelle: Thank you for your comments! It occurred to me the other day that weighing the nail would be a measure....I like Mary’s idea of measuring the rust scrapings. I agree with you all that some kind of design has to be made to depict and communicate, to let us rusters know, as well as convey our beliefs to each other.

Mary: Re: rust weight, I don’t know where to find a scale with fine enough measurement capability, though maybe they have one at the HS.

In her journal, Michelle recorded how she followed through on several of the suggestions and some new ideas of her own. She drew pictures with the aid of computer graphics. She took photos, but found them misleading. She also devised a “verbal scale for rustiness” to define the types/stages of rust (e.g., “rust blood or powder: oozes from immersed nail, sinks to bottom of container; small flakes: float away, specks are visible; ash stage: nail can be broken or crumbled by bare hand”).

Teachers ably questioned and self-critiqued their investigative process. This was a component of each participant’s inquiry process whether it involved reassessing preconceived ideas, acknowledging the need for more study, or rethinking their investigative design. The interaction between teachers appeared to facilitate their inquiry process. Course participants related that, although initially they may have had some uneasiness posting their ideas for everyone else to see, they felt that the course format provided a safe place to share. One teacher pointed out:

[The course] was a little bit scary, then it was fun...sometimes I’m very critical [of] my own writings....Sometimes I would go...online and see, I think it was Mary, she was always first and always thorough. I would be like “errrrrr!” But what was good about it was that I thought she was very bold. I think what I’m trying to say is that I was scared and hesitant to post something not knowing how it was going to look. “Is this what they’re looking for?” Some people, myself included, will inevitably sound better on paper after...having a] chance to edit, think it through.... So this way would be easier for me in terms of...[a] style of communicating.

Another teacher pointed out:

You know it was motivating to go and see...if anybody answered my thoughts...when I posted a message. I always went to see if anybody answered. Maybe now that I’m not so afraid of science, I might enjoy an adult science course, but I really don’t know. I don’t think I would ever sign up for one for fear that I would be the least knowledgeable person in class. Over the Internet, it was more comforting to know that I was just out there in Cyberspace, and nobody really knew me, and I could type in anything….The anonymity was comforting. (laughter) I could ask a silly
question, or I could ask whatever and write it... and...I wouldn’t have to see their faces in disbelief that [I] asked this question. And people wrote nice [things] back, “Oh, I know what you mean.” That was a nice part of it.

One participant described how the online setting differed from a traditional course:

Frequently, you might interact with people you know in the class but you don’t have to interact with everyone in a class...unless you’re in a small seminar type....It's usually...more the teacher has set-up the issues you’re going to discuss....[There was] certainly more [peer communication] than a lecture course --even more than a lab.

In addition, the online format allowed more space to talk. A teacher said:

When you post your responses - it’s different than sitting in a classroom setting where not everyone might get a chance to speak.... Some people in a group discussion want to talk to all the time, not that they don’t want anyone else to talk. So you have that kind of group dynamics that the design set-up eliminated that which can be problem for all teachers and learners.

In the online setting, there were no interruptions from instructors and other students; there was no need to “share air time” with others. There was no limit to how much one could report about whatever, and all “voices” could be heard.

**Bridging Science Content and Teaching Practice**

In the online courses, teachers actively explored science content through experimentation and scientific inquiry and reflected on these experiences individually and with their peers. As teachers engaged as learners, they gained first-hand experiences in inquiry-based learning and teaching.

Teachers reported how they could then draw upon these experiences when designing comparable learning opportunities for their students (See Table 2).

When asked whether the chemistry course influenced their teaching methods and/or if they used any of the experiments in their classrooms, one teacher commented: “I feel more secure in teaching chemistry concepts. I ask students to hypothesize about what would happen if...?” A second teacher responded: “...the course gave me a broader depth of understanding, which enhanced my teaching” and, also, “The activities from the online course added several more quick lessons to my curriculum.”

A third teacher shared the following:

One change that I have definitely added since taking the Chemistry course is having the students “make predictions.” I often remind the students how important it is that everything should be constant in their experiments except for the testing condition, in which this chemistry course reinforced. ...[In addition] I have modified some of the activities. One activity we did during the course was to determine the properties and behavior of atoms and molecules using food coloring that we added to warm and cold water. ...I also use the activity in which two pieces of tape are temporarily taped to the same surface. Then they are removed and show how they repel each other. Students again make predictions before and during the various steps of the demonstration.

The following teacher commented on his recent classroom experience with “Making ‘Sense’ of Surface Tension”:

I actually used this activity the other day as a kind of fun activity to settle in the class on a Friday.... Many of them have done this experiment before, however most were quite surprised. We talked about surface tension and cohesive forces, and I...
Table 2. Course linkages to teachers’ practices

<table>
<thead>
<tr>
<th>Participant / Teaching Link</th>
<th>SE1</th>
<th>SE2</th>
<th>SE3</th>
<th>SE4</th>
<th>SE5</th>
<th>SE6</th>
<th>CH1</th>
<th>CH2</th>
<th>CH3</th>
<th>CH4</th>
<th>CH5</th>
<th>CH6</th>
<th>CH7</th>
<th>CH8</th>
<th>CH9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicates increased confidence in teaching science concepts and/or inquiry processes.</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indicates increased content understanding, which enhances teaching.</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reports use of course activities in science classroom.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indicates incorporation of inquiry processes (making predictions, asking questions, designing investigations, etc.) in classroom teaching.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provides students with more autonomy in their science investigations.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incorporates more opportunities for students to write about their science activity.</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incorporates more opportunities for students to talk about their science activity.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: SE1=Science Education Teacher #1; CH1=Chemistry Teacher #1; X = indicates teacher’s linkage of course to teaching practices; shaded boxes = indicates survey data not submitted.
Providing Elementary and Middle School Science Teachers with Content and Pedagogical Professional Development in an Online Environment

Importantly, teachers came to see how active learning is critical to students’ gleaning of new knowledge and understandings. Although the overall topic of study for the SE project (rust) was predetermined by the instructors, the teachers had a great deal of say and ownership within the project. Teachers decided what questions to explore, how to design for their experiments, what was important to observe, what data to collect and how to go about collecting it, how to resolve problems, and how to redesign. They also interpreted their data and constructed their understandings based on the results of their investigations.

One teacher noted that the investigation design aspect was the most challenging, and yet, it helped her see the openness of science and how she could be more open-ended in her teaching. She said:

*I felt comfortable...to come in and say, okay, this is the question. What are all the different ways we can look at the question. Feeling like there were no tidy boxes or correct answers. The most important thing was the inquiry - to get kids interested and stimulate [their] thinking....I think I'm much more open ended. I was always open-ended - it's kind of my personality, but I think I'm much more open-ended now.*

Another teacher described how the students in her fifth-grade class engaged in the rusty nail activity with her.

*The fifth graders... rusted nails....did [Internet] searches on rust, and...learned that there were businesses that were very actively interested in preventing rust. We...[made] a list [of] where the children had observed rust through the weekend — that was their homework. At the very, very end...the fifth grade had... made up their own experiments — what they wanted to do was to see what substance would rust nails faster or retard rust and so on....*

She explains:

*They don't want to hear about variables. I partake in experimenting with them, explaining why I am using two bowls, one with salt and one w/out salt. Someone adds a galvanized nail to each of my bowls...The galvanized never rusted--yet. Although we had talked about galvanization, and I showed info on a web site about it, one student was intrigued by these nails and asked,” Why didn’t those get rusty?”*

*One child showed me that he was going to rust a nail quicker by coating it with Vaseline. “What will the Vaseline do?” I asked. “Add moisture and keep the moisture in so more rust will happen.” The next week he was SO EXCITED. “I made a discovery!” he crowed. “Vaseline prevents rust!!!!!”*

This teacher indicated that, as a result of her experience, she “will be less rigid....

Instead of dealing with vocabulary first, the vocabulary will come last. Instead of telling students what they will find, asking them what they found.”

Another teacher indicated that she had “a new way of looking at science...the importance of asking the right question at the right time... and [students] being able to write a lot about what they’re learning and just the whole thinking component.” She indicated that she had become “patient with kids and really let them come to their own meanings...come up with questions and their own kind of inquiries.” This was evidenced in a plant unit that began with her asking her class:

*...to collaborate in groups of four to come up with things they already knew about plants and what makes a plant grow, what they thought they knew about plants, and what they would like to find out*
about plants... The kids were excited to get going. This list became the focus of several weeks of inquiry as we began our study.

The SE course participants had autonomy in the rusty nail activity. Their questions, ideas, interests, and skills were acknowledged, addressed, and built upon; they were able to set goals and plan next steps in their investigations; and they explained and justified their work to themselves and others. Their experience influenced several of them to provide students with a voice in their science learning. As one teacher noted, it was important to “[let] the children have the reigns more.”

**DISCUSSION**

**Scientific Inquiry Online**

At the forefront of the *Next Generation Science Standards (NGSS)* is the view that learners “cannot fully understand scientific ideas without engaging in the practices of inquiry and the discourses by which these ideas are developed and refined” (NGSS, 2013, p. 48). Thus, it is critical to not only ‘know’ science content but to be able to use “understanding to investigate the natural world through the practices of science inquiry” (NGSS, 2013, p. 48).

Evidence from this study shows that hands-on, scientific inquiry can be designed for the online environment. Teachers experimented with locally-purchased household materials, with additional equipment and materials acquired from a science supply company. During their investigations, teachers explored research questions, designed procedures, collected and analyzed data, and reported findings.

Meaningful and autonomous science inquiry was key to teachers’ participation. They had much to report regarding the questions asked; the design of their investigations; and the critique of their exploratory processes and thinking. This provided them with a science that was authentic and constructed. Teachers also came to appreciate the value of scientific practices such as making predictions and observations, engaging in open-ended investigations, and synthesizing and communicating findings.

As a result of these experiences, several teachers reported being more receptive to using such approaches in their classrooms (see Table 2). Several noted the value of asking the “right” questions, engaging students in making predictions and allowing them more autonomy with their science. Many described taking course activities directly to their students and others reported engaging students in the same research explorations they were investigating in their course.

**Scientific Discourse Online**

The online environment provides an ideal forum for engaging teachers in science content and teaching practice and providing time and space for thought, discussion, and reflection. In addition, in these courses, the online interactions between teachers were an integral part of their scientific investigations.

The course structure provided participants with more space for talk than the traditional classroom context and, for some, a more comfortable space. All voices were heard since learners could equally contribute to the discussions. In addition, the anonymity of the online environment, created, for many teachers, a safer setting to ask questions; to share ideas, experiences, and difficulties; and to provide support, critique, and suggestions.

These online settings were rich in science talk and were cooperative and constructive. This provided an inviting setting for participants to share their inquiry process, read others’ science doings, and reflect upon their peers’ explorations and their own. Participants found the setting to be supportive and critical to their learning process.

Several approaches can be used when designing online forums based on size (whole class, small
Providing Elementary and Middle School Science Teachers with Content and Pedagogical Professional Development in an Online Environment

Group, or individual journals) and focus (science content, teaching practice, or both). The instructor’s efforts are key to enabling course participants to build social connections; requiring teachers to respond to classmates’ posts appears important. As teachers come to recognize the support of their peers, they often become self-motivated to review, analyze, and discuss their peers’ contributions.

Engaging, productive questions (Eltsgeest, 2001) are key to launching learners into reflection about natural phenomena and observations of investigations that they or others have initiated. These can begin with the simplest questions (e.g. “What do you notice? What happens?”) to those that involve measurement and comparison. “What would happen if” questions (e.g. “What would happen if you placed the nails in boiling hot water?”) are of “great value...to explore the properties of unfamiliar materials, living or nonliving, of forces at work, and of small events taking place” (p. 39). Problem-posing questions set up real situations that, after a bit of exploration with materials or phenomena, learners can engage in enthusiastically, much like asking the SE teachers to make a nail as rusty as possible. Lastly, reasoning questions, such as “Why do you think...?”, engage learners in looking at evidence to make sense of an event and/or experience. Instead of focusing on the “right answer,” the emphasis is on building on ideas that individual students bring to the course. Such a questioning atmosphere is counter to the traditional science classroom where there is a right answer, usually held by the instructor. In contrast, learners engage in sharing ideas and questioning and, together, build knowledge and understanding.

Learners, whether children or their teachers, need to focus not only on “what we know” but also “how do we know what we know,” “why do we believe what we know,” and “what should we do to find out?” (Sampson, Grooms, & Walker, 2010, p. 253). Having learners construct an explanation for what they observe and/or experience requires them to “clarify their thinking, to generate examples, to recognize the need for additional information, and to monitor and repair the gaps in their understanding” (p. 253). Like Michelle’s experience, “[i]t also requires [them] to learn and use the criteria by which these explanations...will be judged or evaluated” (p. 253).

Furthermore, student-student interchange is vital as “socially meaningful activity is prerequisite to cognitive development” and critical thought (Waltonen-Moore, Stuart, & Newton, p. 305). Course instructors play an important role in designing questions and structures that launch students’ inquiries; encourage them to share their learning processes, observations, and questions; and foster critical dialogue that leads to student understanding.

Teachers valued these in-depth, online discussion opportunities. Several noted that they provided increased opportunities for student science talk. However, none discussed ways to incorporate online discourse in their classrooms. A key question to explore would be how teachers might incorporate approaches and technologies in their classrooms that increase students’ science dialogue?

Limitations of the Study

In this study we sought to describe the characteristics of two online courses from the perspectives of elementary and middle school teachers, who were participants. Specifically, how did these online courses engage teachers in inquiry, meaningful discourse, and make connections to their classroom practice, and of what value was that to the course participants? We did not seek to report a causal relationship between a particular “treatment” in each course and subsequent “results”. External methods were not employed to determine participants’ learning.

The study did not include observations of the participants’ classrooms. Researchers relied on teachers’ descriptions of methodologies and les-
sons they implemented as reported in discussions and through surveys and interviews.

The second author of this study was one of the instructors for the SE course. To address potential effect, interviews were conducted after the course was completed. A researcher, not associated with the course, conducted one round of interviews. A graduate student, who assisted with the course, conducted a second round.

Finally, given the distributed nature of online courses, it was difficult for the researchers to “observe” teachers engaged in certain course activities. For example, as they conducted experiments and reported their findings, we analyzed teachers’ descriptions of their participation in these activities as reported in discussion forums, journals, surveys, and interviews. While a teacher might not have described a specific inquiry process, this does not mean that it did not occur; the reverse should also be considered. Ways to address this in the future might be to ask teachers to video-record themselves as they conduct experiments, or to explicitly ask them if they engaged in specific inquiry processes and to request examples.

**FUTURE RESEARCH DIRECTIONS**

As we reflect upon these study results and the existing scholarship in online PD, future research would prove useful in supporting the growth and development of rigorous online PD for science teachers.

One research direction could focus on impacts on teachers’ practices. To what extent do teachers, who have engaged in online PD, implement instructional changes? How do these changes impact student learning? As noted by Desimone (2011), PD should provide opportunities for teachers to improve the content of their instruction and their pedagogical methods. Building on this theme, what types of online PD activities are most beneficial to teachers’ learning of subject matter and pedagogical approaches? The online environment provides multiple ways for teachers to interact with content and each other as they explore concepts, approaches, and resources. Identifying “best practices” for the online PD of science teachers would be greatly beneficial.

A second research direction could explore online instructional approaches. What discourse practices, initiated by instructors, are most beneficial to promoting teachers’ subject matter and pedagogical learning in online science PD? Are open-ended simulations or the exploration of data-sets effective approaches to engage teachers in inquiry and support their learning of subject matter and pedagogical learning? By exploring the interactions between instructor-teacher, teacher-teacher, and teacher-content, these findings would greatly inform online PD instructors and developers as they design course assignments, discussions, and activities.

Finally, a third research direction could focus on changes in teachers’ attitudes and beliefs. How do teachers’ confidence levels for teaching specific subject matter change following engagement in online PD? How do teachers’ views of the nature of science and scientific inquiry change after engaging in science practices in online PD? How does online PD impact teachers’ willingness to use collaborative instructional approaches and web-based technologies? Again, these findings would greatly inform online course developers and instructors, while also providing insights into how online PD impacts teachers’ beliefs and practices.

Such research directions would greatly inform teacher educators, instructional designers, administrators, and key stakeholders, not just in science education but in other PD fields as well. These findings would also provide support for online PD, strengthen learning opportunities for teachers, and lead to new research directions in the field of science teacher PD.
RECOMMENDATIONS AND CONCLUSION

By overcoming time and distance barriers, online programs can provide teachers with access to PD who otherwise are unable to engage in such opportunities. In many cases, online coursework may be the only option for extending their subject and pedagogical knowledge.

In this study, we show that teachers benefit from engaging with course concepts as learners as they conducted experiments, discussed findings, and proposed explanations. This approach provided teachers with first-hand knowledge of what their students would experience in similar conceptual explorations. Also, since these teachers were working from a distance, they had to conduct their own experiments and could not rely on the “expertise” of a lab partner by their side. As a result, each teacher was fully engaged in the experimental process.

As educators design experiments for online science PD, they need to provide opportunities for “guided inquiry”--where participants conduct an experiment within certain parameters and design an extension based on their observations. Online PD should also engage teachers in open-ended inquiry--where participants identify questions and test variables from the start. Both forms of scientific inquiry would provide teachers with concrete, first-hand experiences learning science content and processes.

Although the teachers in this study experimented individually, they were part of a community of teachers who engaged in the same processes, and who served as a resource as they discussed findings, debated explanations, and proposed extensions. These teachers were supportive and readily offered suggestions when a classmate had questions. They formed strong communities as they explored scientific concepts and shared findings, questions, knowledge, and resources.

In working towards building communities, teacher educators should design online PD that includes multiple formats for interaction (whole class discussions, small group forums, individual online journals). These provide opportunities for participants to articulate and reflect on their learning. Discussions should begin with productive questions that encourage prediction, observation, reflection, thought and a range of responses. Journals should provide opportunities to reflect and expand on course activities, experiences, and interactions, and to apply their learning in the context of their classrooms. The teachers in this study greatly benefited from such exchanges; these interactions also provided the instructors with information regarding the teachers’ explorations and perceptions.

Finally, as is the case with all PD, it is important to link teachers’ content learning and experiences with instructional practices in their classrooms. The online courses studied for this chapter provided teachers with opportunities to explore new topics and consider relevant teaching approaches. The results, shared online, provided a rich set of resources that teachers could draw from when developing learning activities. Since these online interactions were text-based, this information could be readily saved and referenced at a later time.

In sum, this study’s themes – inquiry-based teaching and learning, online discourse and reflection, and linking theory with practice – closely align with the standards for the PD of science teachers as outlined in the NSES (NRC, 1996). These standards state that PD programs should involve teachers in actively investigating phenomena that can be studied scientifically; build on the teacher’s current science understanding, ability, and attitudes; incorporate reflection on the process and outcomes of understanding science through inquiry; encourage and support collaboration among teachers; make connections between science and science teaching; build on teachers’ current knowledge of science content, teaching, and learning; model and guide science teaching.
practice; and provide opportunities for reflection, feedback, and support during PD activities.

The mix of individual investigation, group interactions, and individual reflection in these two online PD courses provided teachers with many opportunities to explore and engage in course concepts and reflect on their teaching practices. Upon completion of their studies, teachers reported that these online courses were applicable to their classroom curriculum; they gained new insights into the teaching and learning of science that will improve their teaching; and they expected to use or adapt inquiry-based activities from one or more of their online courses.

**AUTHOR NOTE**

This research was funded in part by a grant from the National Science Foundation 0243536.

**REFERENCES**


Elstgeest, J. (2001). The right question at the right time. In W. Harlen (Ed.), *Primary science...taking the plunge. How to teach science for effectively for ages 5 to 12* (pp. 37–46). Portsmouth, NH: Heinemann.


Lee, J., Bray, M., Carter-Wells, J., Glaeser, B., Ivers, K., & Street, C. (2004). *Discovering the meaning of community in an online master’s degree program.* Paper presented at the meeting of the Association for Educational Communications and Technology, Chicago, IL.


**ADDITIONAL READING**


### KEY TERMS AND DEFINITIONS

**Online Course:** A course delivered via the Internet, providing a means for content delivery, assignment completion, and synchronous and asynchronous communication for learners in different locations.

**Online Discourse:** Ways of talking in the online environment.
**Professional Development:** Continuing teacher education in content knowledge and instructional practice.

**Reflection:** The process of examining one’s thoughts in relation to new observations, experiences, and information, and considering how this may shape and influence one’s beliefs.

**Science Discourse:** Ways of talking in the field of science.

**Science Education:** Study of science teaching and learning.

**Scientific Inquiry:** Practices that scientists employ as they investigate the world.