Preface

Purpose

There is an enormous and swiftly growing literature for online learning practices, but relatively little attention has been paid to the special attributes and pedagogy of online science at the community college and university level. As regular authors of natural science courses and instructional materials for the online program for adults at DePaul University, we have long wondered why there was no up-to-date and expansive examination of the best practices in online science learning for university faculty, no general survey of current and emerging technologies for teaching science online, little consideration of the role of online science education as a burgeoning force for building American and global science capital, and no pragmatic models to inform the comprehensive development of online science programs, courses, and constituent learning activities. This book concentrates on this void by providing a general treatment of online science learning in the sciences—a subject area we affirm is an emergent and vital area of science education. While we review and incorporate selected examples from vast literature in computer science and engineering, we have purposefully constrained the chief focus of our treatment to online science learning in the natural sciences. The other fields within the science, technology, engineering, and mathematics (STEM) knowledge areas are certainly deserving of comprehensive treatments of their own online learning practices, but are beyond the scope of this book. Likewise, while our approach is largely U.S. in focus, we have tried, whenever possible, to incorporate non-U.S. considerations and concerns, and hope that this effort is apparent.

Educational Context

The current fervor over distance learning in schools and universities inspires the impression that it is an educational construct borne recently of the computer age, but this is certainly not the case. For almost two centuries, learning separated spatially from teaching has been an approach to acquiring knowledge (Bell & Tight, 1993). In contrast, online learning is a relatively young format for distance teaching and is fostered by and parallels the contemporary
revolution in communication and information technologies (CIT). The rapid proliferation and tacit acceptance of online instruction in higher education and school instruction has effectively made the terms “distance education” or “distance learning,” in practical usage, synonymous with “online learning”. Likewise, the term “distance education” is often used interchangeably but unsuitably with “e-learning”, which is actually learning that relies on CIT technologies in a variety of contexts; thus it significantly overlaps, but not necessarily involves, distance education (Guri-Rosenblit, 2005).

In the hierarchy of learning forms in the “lifelong learning” framework (Figure 1), online science learning is nested within distance learning, e-learning, and online learning, respectively. Other important learning types such as blended learning (also called hybrid and mixed) and mobile learning (also called m-learning) can also be used in conjunction with online science learning.

**Organization and Character of the Book**

*Online Science Learning: Best Practices and Technologies* is organized into five sections (Figure 2) spanning: (1) fundamental issues and concepts in online science learning, (2) emerging online science practices and technologies, (3) assessment of online science activities, (4) current online practices in mathematics and natural science disciplines, and (5) a detailed instructional design model to develop online science activities. Section I reviews the value of science education in terms of scientific capital. It also evaluates global and national
trends in both science and online science education. In addition, this section examines the epistemological and pedagogical foundations of online science and introduces the character of online science in schools. In the final chapters of this section, contemporary online science practices in higher education are investigated and the essential topics of practical work and collaboration are reviewed from the online science perspective.

In Section II of this book, we appraise and provide examples of contemporary approaches in online science instruction and review emerging technologies that may soon significantly affect the character of how science is taught online. Our book’s Section III provides a review of best practices in online assessment of learning, including specific applications to online science learning. In Section IV, we compile and review a substantial number of best practice cases of online science from recent publications in the physical and chemical sciences, earth and environmental sciences, and the life sciences. Our book’s final section is devoted to presenting an instructional best practices model for developing online science exercises, courses, and programs. Our model is didactic and derived from a hypothetico-predictive philosophy consistent with the neurological basis of human learning. This section also provides course authors and designers developmental worksheets to aid in the various designs or redesign phases of an online science course or learning activity.

Figure 2. Organization of Online Science Learning: Best Practices and Technologies
Online science learning can be a remarkably visual-rich experience and we have attempted to bring some of its vitality through to the reader with the graphics used. We note that our publisher’s cost considerations prohibit a printed color version of this book. However, the reader is encouraged to access the digital rendering of this book, which is principally in color.

A brief description of each of the chapters follows:

Chapter I provides an overview of the state of global science capacity and online science education initiatives designed to increase that capital, with emphasis on developing countries. We briefly describe the valuation of science education, and establish a base from which advances in online science education is explored in the remaining chapters.

Chapter II evaluates trends in online science education within the context of the biggest issues in contemporary science education, the ongoing debate about the definition of science, the proper role of science education and the steps necessary to correct the science gap in the United States. Almost by definition, this controversy falls along theoretical camps—the variety of constructivists versus the movement toward a hypothetical-predictive learning theory more tightly bound to the neurological (i.e., biological) source of learning.

Chapter III provides the reader a foundational look at the contemporary character and role of online science learning in virtual schools. With an emphasis on secondary schools, we examine the interdependence and existing obstacles to seamless K-16 science instruction. The affordances of the online science environment to generate a more connected science education strategy for students from K-12 through their university studies are investigated, including the crucial area of professional development for science teachers. To illuminate the salient similarities in the character and efforts between online science learning at schools and universities, we conclude this section with a comparison of practices and technologies applied commonly to each. We offer general guidance on areas of online science learning that can be capitalized on to improve student learning in science within our schools.

Chapter IV presents an investigation of the current use of cutting-edge science technologies and explores the pedagogical foundations of online science education that effect how use choices are made. We examine strategies consistent with the neurological basis of learning linked to hypothetical-predictive processes and where those strategies are currently utilized.

Chapter V reviews and defends the concept of practical work and its use to support online science instruction. We review practical work’s historical foundation, purpose, and value, as well as controversies concerning practical work’s utility in science instruction. This chapter builds a rationale for practical work’s intentional implementation in online science learning environments and supports subsequent chapters that review current and emerging approaches and technologies to support online practical work.

Chapter VI provides a general overview of online collaboration but emphasizes the role and types of collaboration useful to teaching science online. This chapter reviews models and effective approaches to online collaboration including establishing greater lifelong learning ties to scientific information through lasting forms of collaboration facilitated online.

Chapter VII presents an analysis of the key forms of contemporary online instructional design concepts and practical work approaches to online science learning such as learning objects, simulations, remote laboratories, and virtual field trips. Our discussion incorporates best practice examples, which form the groundwork of an extensive review of disciplinary science examples in Chapters X-XIII.
Chapter VIII reviews and encourages the use of innovative technologies to promote effective online science learning. This chapter considers the outlook for the character of online science learning in the near future synthesizing recent research in the CIT and online technology areas.

Chapter IX reviews current and emergent best practices in online learning assessment, notes similarities in on-site and online methods, and explores the differences and how those differences are or can be addressed. Particular attention is paid to the assessment of typical online science activities (e.g., practical work) and troublesome theory incongruities (e.g., discrete knowledge).

Chapter X provides a review of best practice cases in online science from mathematics and the physical sciences. Examples are grouped into the chief areas: courses, simulations, virtual laboratories, collaborations, virtual science museums, and digital libraries. This chapter provides a foundation of resources to consider in the development or redesign of math and physical science learning activities and courses.

Chapter XI’s focus is to present a more discipline-centered review of representative published examples from the geosciences. Our review takes account of courses, virtual field trips, virtual laboratories, collaboration, virtual science museums, and the relationship of the cyberinfrastructure to the geosciences. This chapter provides a variety of resources to consider in the development or redesign of online earth and environmental science learning activities and courses.

Chapter XII reviews representative published examples from the life sciences. Our review takes account of courses, virtual field trips, virtual laboratories, collaboration, and virtual science museums. Our goal is to provide the reader with an appreciation of the best practices, innovations, and initiatives in online science in the life science area.

Chapter XIII presents our didactic model for online science instruction based upon best practices in both science education and online education coupled with insights from the diverse and substantial literature reviewed in previous chapters. We blend concepts of distance education and science into a practical model that addresses the learning needs of major and non-major students, and the instructional design constraints of their instructors and institutions. We approach the instructional design topic with the assumption that the published online modalities included herein are generally effective as presented, but have noted evidence of ambiguity, where found. The summation of this treatment is an integrated model that takes into account emerging ideas about the neurological basis of human learning and consideration of the different philosophies of science education, although we make no apologies for holding a particular perspective. Our chief goal is to present the reader a process flow and supporting development tools through key course design steps bringing together original learning design structures with sensible best practices from the literature.

Who is This Book For?

We have written this book with the intent of serving several audiences within the science education community of practice. Foremost, our book is intended to serve as a practical resource for science programs and community college and university-level science instructors building new and/or transitioning existing aspects of their science curriculum or courses,
whether fully online or blended. Accordingly, we provide both a theoretical and practical background on online science learning as well as a model for course development. Moreover, we have deliberately presented many of the best practice cases organized by key scientific areas so that science educators can get a quick view and be inspired by contemporary best practice examples in their own mathematics or natural science disciplines. Although our perspective is through the window of science, our hope is that practitioners of online learning from other disciplines will also find the topics, review of technologies, and strategies informative.

In addition, this book should be useful for instructional designers involved with the development of online scientific materials. We anticipate that this book will enhance the dialogue between instructional design staff and science faculty. Utilizing this book’s analysis of practical work and collaboration as well as its review of socio-economic (i.e., valuation) aspects of science, trends in online science, and online science pedagogy; this tome can be employed as an effective resource or text for education department courses on science at the upper division and/or graduate level. Similarly, with the rapidly growing interest in augmenting K-12 education with online activities and resources, this book is also intended as a reference for secondary school educators and administrators. Lastly, we share deeply in the concern regarding America’s “failure” in science education over the last few decades and its long-term consequences for America’s prosperity. Consequently, this book is intended to inform and motivate policy makers to explore and make the most of this important and emerging area of science instruction to increase scientific capital, both here and abroad.

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References
