Preface

As the IT industry advances, cloud computing represents the next big platform change in e-learning. Due to its stability, flexibility, security, availability, and low cost, cloud computing has various applications in educational organizations. Cloud computing will literally revolutionize the way of teaching and learning.

In particular, the cloud technology has created great excitement in STEM education which can benefit from many features of the cloud technology. Cloud computing can significantly reduce the expenditure on computer lab construction and maintenance. The cloud-based learning environment encourages learners to be actively engaged in the learning process. It also promotes collaboration in group projects. Due to these features, the cloud technology has been widely adopted by a large number of schools and universities throughout the world. It has been used to support Web-based software development, integration of engineering drawing and data, big data analysis and processing, virtualization of labs, implementation of virtual reality, and so on.

This book is designed to prepare instructors and students for the new cutting-edge learning environment in STEM education. The book aims to discuss and address the advantages, difficulties, and challenges that STEM education has faced in adopting cloud computing. It has collected chapters that address different aspects of cloud adoption, ranging from virtual lab construction, app development, social networking, software support, information sharing, collaboration platform development, IT infrastructure development, information sharing, course material distribution, and related topics. Additionally, the book explores the impact of cloud computing on STEM education and analyzes the acceptance of cloud-based learning in STEM education. This book provides the much needed information to help educators and technology professionals in understanding the theories and concepts of cloud computing and its application in e-learning. To help readers better understand and apply the cloud computing technology in teaching and learning, the book provides research studies on the following subjects.

- Cloud adoption in STEM education
- STEM requirements for cloud computing
- Learning STEM subjects in the cloud environment
- Support for cloud-based scientific application software
- Support for cloud-based mobile learning
- Impact of cloud computing on STEM education
- Barriers to cloud computing in STEM education
- Security issues related to cloud applications in STEM education
- Case studies on cloud applications in STEM education
- Pros and cons of cloud computing in STEM education
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- Open source cloud products used in STEM education
- Strategies and practice of cloud-based learning environment implementation
- Cloud-based learning platforms
- Cloud accessibility
- Cloud services for STEM education
- Cloud-based social networking
- Cloud-based collaboration platform development
- Cloud technology for virtual STEM lab development
- Cloud technology for information retrieving and sharing
- Cloud technology for infrastructure development
- Evaluation on the effectiveness of cloud computing on teaching and learning

This comprehensive and timely publication aims to be an essential reference source, building on the available literature in the field of cloud applications in STEM education while providing for further research opportunities in this dynamic field. It is hoped that this text will provide resources necessary for policy makers, educators, students, technology developers and managers to adopt and implement the cloud-based learning environment in STEM education. The book includes research studies in cloud system implementation, cloud computing architecture and its support to IT infrastructure. It includes the first hand experience provided by the authors who are researchers, educators, and practitioners in various STEM fields. Some of the authors provide solutions for the implementation of cloud infrastructure to support STEM education. Some of them discuss policies and security issues related to the cloud system for STEM education. In addition, some of the authors present their research results for the class and lab management with the cloud approach. This book also presents evaluations on the effectiveness of cloud-based teaching and learning on STEM subjects.

Due to its complexity, expense, and high demand on technology, STEM education requires a computing platform that has flexibility, security, availability, scalability, and affordability. The cloud infrastructure provides a solution that can meet the requirements by STEM education. Financially, small educational institutions can particularly benefit from a cloud infrastructure to support their STEM programs since a cloud infrastructure can significantly reduce the cost of IT expenditure. Using the cloud infrastructure can also improve computing availability. The SaaS service provided by the cloud allows students to access software through the Internet. The cloud infrastructure can also improve security. With the IaaS service, students are allowed to create their own IT environments with virtual machines. In the virtualized environment, the students can have the administrative privilege to learning and practice the management of servers and networks without harming the underline physical network. The cloud infrastructure is flexible so that the virtualized computing environment can be specially designed for each individual course without changing the underline physical IT infrastructure. The cloud can also improve collaboration among a group of students. With the PaaS service provided by the cloud infrastructure, a group of students can participate in the same application development project. Multiple students can access the same set of virtual machines and watch the same screen of a virtual machine together.

As cloud computing has revolutionized the IT industry, a great number of research studies have been done about the cloud infrastructure and its application in business. On the other hand, the experiences with the cloud approach to support STEM education have rarely been seen. As more and more STEM programs will adopt cloud computing for teaching and learning, a systematic and comprehensive coverage of cloud-based teaching and learning becomes necessary. It is necessary to collect the results of research
on cloud computing and its application in the fields of STEM. This book provides valuable information on the effectiveness, usefulness, performance, availability, and security of cloud-based STEM education.

THE CHALLENGES

Moving from an existing IT infrastructure to a cloud-based IT infrastructure can be a great challenge for an education institution. Although, cloud computing has been widely adopted in the IT industry, for many education institutions, cloud computing brings a new way of supporting their daily teaching and learning. A cloud-based learning environment could create great challenges to everyone who is involved in cloud-based e-learning. For the IT service department, switching from the existing IT infrastructure to the cloud-based IT infrastructure is a complex process. It requires the IT service department to get its IT staff trained on the cloud technology. The IT staff members need to understand the cloud computing first. They need to get familiar with new ideas, new concepts, new devices, new software, new architecture, and new terminologies. The implementation of the cloud-based IT infrastructure requires knowledge and skills. The IT service department needs to make a decision on which cloud technology to use. Although different types of cloud infrastructures have their own pros and cons, the choice of a cloud technology has to be based on the requirements by a STEM education program. The IT service department needs to conduct systematic analyses before making a decision. Before the implementation, The IT service department may need to draft a logical design and conduct experiments to make sure the requirements have been met. The long term effect is another factor that needs to be considered by the IT service people so that they do not use a soon-out-of-date technology to implement the cloud infrastructure. Although the cloud infrastructure allows instructors and students to remotely access computer resources through the Internet, the IT service people need to address the compatibility issues. The cloud infrastructure may not support all the Web browsers or other remote access mechanisms. The IT service department needs to work on the compatibility of the new cloud infrastructure and the existing IT infrastructure. Using virtual machines through the Internet may also generate some performance related issues.

Students, instructors, and administrators need to deal with an unfamiliar learning environment. In the cloud-based learning environment, besides learning the course content, students are required to learn about cloud computing. Learning about the cloud infrastructure may require training and technical support for all the students. The extra time used for the training may reduce the time for students to learn the course content. New ways will be used by the students to communicate with their fellow students and with their instructors. In the new cloud-based learning environment, the teaching evaluation may also be different. The evaluation questionnaire should be redesigned to reflect new teaching methods. Measures should be implemented to make sure that the students can participate in the evaluation process.

There is no question that cloud computing will bring new ways of teaching and learning. This will require instructors to learn more and stay up-to-date with the cloud technology. The instructors need to renew their course materials to adopt the new environment. Lab manuals need to be rewritten to cover cloud computing. Lab activities need to be redesigned so that the students can perform hands-on practice in the cloud environment. For the instructors, class management and student management will also be different. To take advantage of the cloud infrastructure, collaboration activities will be redesigned. The students will be regrouped. The responsibility of a student in the collaboration will be redefined. The distribution of course materials will be done through different channels. The instructors need the training on the cloud technology. In addition to course content, the instructors need to stay ahead of
their students on the cloud technology. The students often rely on the instructors for troubleshooting when there is a technical problem. The instructors and students also need to work together to overcome difficulties carried by the new teaching environment.

Although the cloud-based learning environment is appealing at first, once implemented, many problems may come up due to less thoughtful designs. The administrators of an educational institution need to pay attention to the planning and management of the migration from the traditional IT infrastructure. They need to have a feasible strategy on the implementation of the cloud-based learning environment. By common understanding, the cloud infrastructure can significantly reduce the IT expenditure. However, it may not be the case if the cloud infrastructure is not properly developed. The expenditure for the long-term subscription of virtual machines from a public cloud provider may not be affordable for many education institutions. On the other hand, the development of a private cloud requires a great deal of initial cost. A well designed implementation plan and budget allocation are the key factors for success. During the operation, cost control and security are the main tasks for the administrators to keep track of. The Internet is often considered the weakest link for network security, and cloud computing is established on top of the Internet. It is possible that the new cloud-based learning environment is vulnerable to some security threats. The administrators need to make sure that the new cloud-based IT infrastructure complies with the government regulations. Students’ privacy needs to be protected in the cloud leaning environment. However, in the cloud-based learning environment, student data may not be protected by the campus private firewall. In such a case, an educational institution loses the full control of the student data, which may not be acceptable by many education agencies and governments.

THE ANSWERS

To help STEM programs successfully implement the cloud-based learning environment, this book aims to provide some guidance and solutions to some commonly encountered problems. For readers who are involved in cloud-based teaching and learning in STEM education, or who participate in cloud infrastructure development to support STEM education, they can benefit from the ideas and solutions provided by the book. This book presents the reader some firsthand experience in cloud infrastructure implementation and actual classroom teaching so that the reader can better understand cloud computing and its application.

For administrators who are looking for strategies and practices to establish a cloud infrastructure, this book provides reports that summarize the trend and current status of using cloud computing in STEM education. Readers can learn from both the success and difficulty summarized by the authors of the book. This book includes strategies for developing a successful cloud infrastructure to support teaching, learning, and research in STEM areas. It shows the planning on the adoption of the cloud infrastructure for STEM education. It provides strategies for dealing with the dramatic change in pedagogy. Some tips on cost reduction are also included. This book illustrates the ways of migration from the traditional IT infrastructure to the cloud infrastructure. For administrators, security issues are discussed as the highest priority that they should pay attention to. Two of the chapters in this book are devoted to security issues related to cloud applications in STEM Education. Measures are proposed to protect cloud-based applications and student information.

For readers who are responsible for implementing the cloud infrastructure, this book provides several chapters that cover the different aspects of cloud infrastructure development. These chapters discuss
issues related to cloud infrastructure implementation, from the design to the deployment of a cloud infrastructure. Several research studies related to teaching STEM subjects in the cloud-based learning environment are included in this book. To help readers understand the technical foundation of the cloud infrastructure, this book has a few chapters that provide the first hand experience on the construction of a private cloud and the subscription of cloud services from public cloud providers. It introduces the architecture of Cloud Computing for Education (CCE). It also introduces the cloud learning platform and several tools used to enhance cloud-based teaching and learning. For the STEM online IT education, this book includes a chapter on a Cloud-based Laboratory. This book also addresses network issues related to cloud infrastructure construction. A context-aware cloud-based Personal Learning Environment (PLE) architecture is proposed to show the benefits of the cloud infrastructure on resource sharing. For cost reduction, this book illustrates how to utilize the cloud-based social media as a learning management system (LMS). It also includes an open source based private cloud infrastructure.

For the readers who are planning to teach STEM courses in the cloud infrastructure, this book provides several chapters which cover the use of different cloud technologies to teach subjects such as math and biology. It provides case studies that deal with the real world challenge in implementing cloud-based teaching and learning. By studying these case studies, readers can avoid making the same mistakes. Several chapters in this book illustrate how teaching and research can benefit from the cloud infrastructure. This book demonstrates how teaching and learning can be conducted successfully on a private cloud. It also illustrates how to engage students in conducting data analysis. For developing strong practical skills, an open source cloud simulator is introduced in this book to enhance hands-on learning. In this book, an author demonstrates the use of cloud-based screencasts for improving math learning. Cloud-based mobile learning is also discussed in this book, demonstrating how to deal with various challenges in cloud mobile learning. Cloud computing has been used by an author to promote the interdisciplinary study in information science and I-school.

This book provides multiple chapters that deal with the evaluation of cloud-based learning in STEM education. Readers can find several evaluation methods for cloud-based learning. They can also gain information from the feedback of the instructors and students. The feedback can be used as guidance for readers who want to develop their own cloud-based learning environment. The authors have provided some lessons learned from the inquiry-based learning on the cloud. The effectiveness issues in cloud-based teaching and learning are also addressed. The effectiveness analysis is applied to the cloud-based multimedia solutions. The Continuous Formative Assessment (CFA) technique is introduced for evaluating student understanding to optimize STEM teaching and learning. Through a case study, a cloud-based assessment model is introduced to investigate student perceptions of a cloud learning environment. A feasibility study is discussed on evaluating the IaaS service in the computing and library services of a UK university. Topics such as the negative impact of cloud computing and the situation awareness learning are also discussed in the book.

In summary, the book provides various solutions to combat the challenges raised in cloud-based teaching and learning. When developing a cloud-based IT infrastructure to support teaching and research, readers can find case studies that are useful to help them apply the cloud technology to the enhancement of their own teaching and learning. From the lessons learned, readers can avoid making the same mistakes. They can find plenty of tools and the usage of the tools to create cloud-based teaching materials. They can also find a number of security measures to protect their student data and cloud infrastructure.
TARGET AUDIENCE

In general, this book is for students, instructors, IT professionals, researchers, and administrators who are involved in the development cloud-based teaching and learning in STEM education. The book is designed for readers who want to get a quick start on developing cloud-based STEM courses. It can help instructors make teaching and learning more efficient with cloud computing. Based on the experience learned, the instructors can avoid some shortfalls when developing their own course materials. The book can help decision makers to understand the cost and benefit of the cloud-based learning environment. It provides them with information on how to reduce the cost of running a STEM education institution. It can also help education institutions to improve the availability, security, and affordability of STEM education. It is useful for people who are planning the switch from the existing traditional IT infrastructure to a cloud-based infrastructure. Particularly, IT service staff can benefit from this book which covers the strategies and practice on the construction of the cloud infrastructure. Students can also benefit from this book where they can find case studies on class discussions and term projects. By learning in a cloud environment, students can familiarize themselves with cloud computing and adjust their learning behavior accordingly.

ORGANIZATION OF THE BOOK

Twenty five chapters are included in this book. The chapters are categorized into five main sections: Trends and Advances of Cloud-based Teaching and Learning, Development of Education Cloud Platform, Teaching and Learning in the Cloud Environment, Security and Access Control in Cloud Computing, and Management and Evaluation of Classes Supported by Cloud Platform. The following briefly describes the chapters included in each section.

Section 1: Trends and Advances of Cloud-based Teaching and Learning. Three chapters are included in this section. These chapters describe the big picture of cloud-based STEM education. This section discusses the adoption of the cloud infrastructure in STEM education, the dramatic changes in pedagogy, and the establishment of a cloud portfolio system.

Chapter 1 gives advice on how to strategically plan for the use of cloud computing services and how to identify, weigh and assess various factors in decision-making. Just as with e-learning when it was found at the end of the 1990s that purely online technological approaches were not as effective as pedagogical models (blended learning) which took into account human factors such as student motivation, teacher training, technological illiteracy, etc., the author suggests that a holistic technology adoption process that includes needs assessment and stakeholder engagement will be the most successful.

Chapter 2 considers cloud computing as a technology enabler for STEM education, and it discusses how it requires dramatic changes in pedagogy in order to ensure that STEM education is relevant, useful, and effective in the digital world.

Chapter 3 defines and categorizes c-portfolio; it addresses issues and challenges faced by c-portfolio’s implementation in higher education.
Section 2: Development of Education Cloud Platform. This section includes seven chapters. The chapters in this section focus on the cloud infrastructure construction.

Chapter 4 describes the architecture of Cloud Computing for Education (CCE), which includes a number of steps for adopting and implementing cloud computing. To implement this architecture, the chapter outlines an open framework that can be used as a guidance towards successful adoption and implementation of cloud computing.

Chapter 5 presents a solution that is based on private cloud computing and can be used to build a laboratory and learning environment for a variety of online hands-on IT courses including Wireless System, IP Telephony and Server Application.

Chapter 6 aims at explaining the transport layer limitations, an overview of how we arrived at the protocols used today, and some techniques that could be adopted in the future, with a focus on cloud computing systems.

Chapter 7 investigates a possible replacement for many features typically associated with the learning management system (LMS) with social media. STEM learning may be especially enhanced through the use of social networking service (SNS) as LMS.

In Chapter 8, the authors present a learning platform that is capable of orchestrating learning activities through Web interoperability with Web 2.0 tools. This interoperability is realized through advanced Semantic Web technologies such as JSON-LD and Hydra, and a specialized architecture to automatically recognize, process, and use the tools’ Web APIs.

In Chapter 9, a context-aware cloud-based PLE architecture is proposed, which is driven by a Context-Aware Engine to acquire, filter, and interpret context information based on the preferences defined in user profile, where cloud computing is taken as service infrastructure. An illustrative personal learning scenario is investigated to demonstrate the proof of concept implementation.

Chapter 10 focuses on cloud-based online teaching infrastructure created with free and open source cloud computing. It provides some strategies in developing various cloud-based computer labs for hands-on practice required by IT courses. A case study is used to illustrate the use of the free and open source cloud technology in STEM education.

Section 3: Teaching and Learning in the Cloud Environment. This section includes six chapters. It provides research studies on the cloud-based teaching and learning in STEM education.

Chapter 11 discusses the motivation behind leveraging the cloud for STEM based higher education. The authors use the case study approach and examine two cases. This chapter examines best practices that are involved in developing cloud-based learning systems, progressive delivery mechanisms for course presentations, setting up the required cloud infrastructure, and the operational use of the entire system. The authors aim to give researchers and developers deeper insights into the development of successful private cloud-based STEM-based educational offerings.

Chapter 12 presents the justification for utilizing whole-class data analysis as an important aspect of the Computer Supported Collaborative Science (CSCS) pedagogy and demonstrates how it aligns with the Next Generation Science Standards (NGSS). The authors conclude that the components of CSCS whole-class data analysis help constitute a pedagogical model for teaching that functionally shifts the focus of science teaching from cookbook data collection to pooled data analysis, resulting in deeper understanding.
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In Chapter 13, a hands-on learning approach is proposed for developing strong practical skills, considering an essential element of this approach - the use of cloud simulators. A survey of open source cloud simulators is provided, presenting an exhaustive comparison of the existing alternatives and determining an appropriate set of criteria to decide the best simulator for each learning objective. Two examples of hands-on contents are presented using these simulators.

In Chapter 14, screencasts are discussed from a pedagogical and curriculum perspective using student feedback statistics as data. Specifically, screencasts offer a teaching resource that has value for many traditionally difficult groups of students. The author concludes with some observations of how the overall learning environment might be improved in the context of undergraduate mathematics.

Chapter 15 introduces the evolution of cloud-based m-learning, benefits and characteristics of cloud-based m-learning. It also canvases the current scenario of m-learning utilizing the cloud, various challenges for implementing the m-learning system on the cloud. It further confers technologies used for cloud-based m-learning. It also discusses some methods of creating m-learning content and experiences. The authors conclude with a brief discussion on the future aspects of cloud-based m-learning.

Chapter 16 describes the virtualization technology which provides a remote accessibility of hardware, software, IT resources, as well as application packages. Information schools or the information field not only get information support from the cloud but also other technology support for virtualization. Advanced information services are positively possible to gain up with cloud supported technologies.

Section 4: Security and Access Control in Cloud Computing. This section includes two chapters. This section deals with the important security issues in the cloud learning environment.

Chapter 17 presents a comprehensive overview and a comparative analysis of security methods of cloud applications in STEM education; it introduces a new methodology that will enforce cloud computing security against breaches and intrusions.

Chapter 18 aims to help cloud learning (CL) stakeholders in STEM education (namely cloud service providers, cloud content providers, and cloud users) to better understand the security issues inherent in CL from the perspectives of confidentiality, integrity, and availability. The discussions about the risks that CL stakeholders in STEM education incur as a result of prevailing security threats and system vulnerabilities will help those stakeholders to assess the cost effectiveness of security countermeasures.

Section 5: Management and Evaluation of Classes Supported by Cloud Platform. This section includes seven chapters. This section provides evaluation methodologies on various aspects of cloud-based teaching and learning.

Chapter 19 addresses some effectiveness issues in the cloud-based teaching and learning process by introducing a European initiative called weSPOT (Working Environment with Social, Personal and Open Technologies for Inquiry-based Learning) for supporting and enhancing inquiry-based learning in STEM education via a cloud-based inquiry toolkit. The chapter presents evidence of using this toolkit in a case study that investigates how a secondary education community of students/co-learners selects information sources on the web and identifies factors associated with the reliability of information sources during their collaborative inquiry (co-inquiry) project in online environments.

Chapter 20 introduces and explains Continuous Formative Assessment (CFA) techniques and provides preliminary research pertaining to the effectiveness of CFA instructional strategies in promoting...
Chapter 21 provides an auto ethnographic example to enhance student supervision at a distance using education technologies. This chapter presents a journal-like case-study perspective to show academics and teachers everywhere how utilizing freely available online software might improve the effectiveness of the supervisory experience.

Chapter 22 describes a New Zealand Polytechnic based success story which utilised a multi-method approach to investigate student perceptions of a cloud assessment learning environment. The learning environment factors that are examined in this chapter include progress monitoring, cloud tools (i.e. Google Docs), feedback, cloud storage, technology preference, student achievement, and student engagement. This chapter not only describes this unique learning environment, it also provides a clear insight into student perceptions of the cloud assessment learning environment.

Chapter 23 reports an investigation of Information Technology (I.T.) enablement for a Higher Education Institution (HEI), with focus on the feasibility of Infrastructure as a Service (IaaS) using Cloud Computing. A pragmatist - mixed-methods research approach was followed to establish the Feasibility Study, which included the potential IaaS risks and benefits for a HEI such as the Computing & Library Services of a UK university. An analysis of the advantages and disadvantages, as well as a legal, social, operational and Service Level Agreement (SLA) discussion are provided. Furthermore, the authors outline the potential impact on the institution’s employment. Based on the Feasibility Study, the authors recommend a list of selection criteria and evaluation methods that could be regarded as the basis for a future IaaS Cloud decision model for HEIs.

Chapter 24 presents a media studies interpretation of the impact of Cloud communication technologies on traditional academic achievement. The authors state that, because new technologies in education are driven by commercial interests, its pedagogical value becomes secondary resulting in what social media and other critics view as the dumbing down of the American student. Given the analysis of media communication technologies’ impact on education, the authors then offer a possible way out of the current situation by proposing a more human factors approach towards Cloud technologies based on constructivist educational and cognitive styles theory.

In Chapter 25, the authors present the first theoretical and applicative results that the Italian scientific community has achieved as part of the research lines that revolve around the concept of Situation Awareness (SA).

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